BIRDS AND FOREST MANAGEMENT

HABITAT REQUIREMENTS FOR AUSTRALIAN BIRDS, AND SOME IMPLICATIONS OF CONVERSION OF EUCALYPT TO PINE FOREST.

BY

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FOREWORD

Soon after my arrival to Australia I began taking trips to the bush. Some of the foresters seemed to never stop talking about the remarkable qualities of *Pinus radiata*, a species which I had come to know in California as basically scrub. I on the other hand never seemed to tire of admiring the avifauna in Australia. After attempts at a few other topics, I decided to find out what effects converting the Australian forests to pine plantations would have on these birds.

During my stay in Australia I was introduced to many persons having limited knowledge of forestry but who felt the pine plantings were wrong. There seems to be a basic misunderstanding not only of foresters, but also of foresters understanding the people they are meant to serve.

As my studies were financed by myself and I had an urge to see a bit of Australia in the process, I managed to engage in several endeavours outside of Canberra, and include in the Appendices some areas where I spent some time on the avifauna situation.

My thanks are extended to the several foresters and forest assessors who showed me around the areas; K. Fussell and P. Harper on the Oberon; I. Brilliant and J. McCormack on the Wombat Forest; and M. Boyden and M. Smith in the Fingal area. Guidance from my superviosr, Dr. K. Shepherd is also greatfully appreciated.

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CHAPTER 1

THE NEED FOR CONCERN

1-1 Introduction

As the environmental revolution got underway in the 1960's in America, people around the world joined in concern for the environment. Concern about the environment is with us to stay.

In many areas public opinion has tagged the forester as as environmental polluter. To a considerable degree, foresters are victims of circumstances beyond their control; history, training, education, job requirements, and superior authority often dictate the role foresters will take on environmental matters (Crafts, 1973). Florence (1969) says "the concept of conservation usually reflects the nature of the individual's academic training and professional responsibilities. Conservation should embrace a wide diversity of the concept and be projected in this way if it is to become an integral part of the national attitude and national culture". It is no wonder then that birds receive a low priority in forest management objectives when ornithology isn't even offered as a course at the Australian National University, the main forestry school in Australia.

Changes in the social environment in which forestry is practised have outpaced the profession's capability to respond. It is the practise of forestry, not the individual forester, who must make the changes (Poole, 1974). Until society as a whole demands such things and congress appropriates money for these things, foresters will continue to be educated and trained in traditional methods, and if they want to do some special study on butterflies, birds or wildflowers it will have to come in their own spare time. If foresters fail to meet the challenge of environmental concern, the profession will retrogress in national prestige, respect and effectiveness. Instead of being leaders in the conservation movement, "the forestry profession could be downgraded to a vocational trade school for loggers" (Crafts, 1973).

Foresters must do more to measure and put values on all non-timber forestry benefits if they are to continue to manage the forest estate (Moulds, 1971). They will find it necessary to convince the government that they are the appropriate authorities for administration of these resources.

Most decisions concerning the forest are based on economic criteria. Maurice Strong (1973), Director of the United Nations Environmental Program made the following comment:

> In the sphere of sectoral decision-making and action, simple tests such as profitability--often short-term--form the basis for embarking upon an activity which may impose severe, long-term costs on the public and may produce adverse effects that are outside the sector originating action. If one wanted to carry current concepts and methods to the extreme, given current interest rates and carrying present methods of cost-benefit analysis to their logical conclusion, it would not be good economics to preserve the oceans, the atmosphere or other precious resources of the

> earth for the next generation. On a purely economic basis, in fact, it would just not pay to save Planet Earth!
> One of the dangers of a purely economic approach is its inherent narrowness and short-sightedness. Imagine how little would be left today of the impact of Greece and Rome on human development if these societies had made all their major decisions on the basis of the economic criteria we apply today to so many of our decisions.

Webster and Gordon (1975) believe the forestry profession must launch a vigorous effort to do no less than reawaken in its contempories a positive vision of the far future, with renewed deep, concern about society's long range time perspective.

1-2 The Conservation Movement in Australia

In the early 1970's in Australia several publications came out condemning the take over of Australian forests for pine plantations, woodchipping and intensive management, chargimg the following deleterious environmental effects: (Routley and Routley, 1973; Jones, 1975; Australian Conservation Foundation, undated; Roberts, G., undated; Friends of the Earth, undated).

1). Loss of scenic value and recreational amenity;

2). Declining soil fertility through leaching of nutrients, erosion of the soil surface, and the continual removal of nutrients locked up in the standing crop of trees;

3). Siltation and possible eutrophication in water catchment;

4). Depletion of cut over area's value as a water catchment;

5). Reduction of floral species with native species being replaced by exotics;

6). Reduction of faunal species;

7). Increased incidence of disease pathogens due to soil disturbance and disturbance of drainage patterns;

8). Increased susceptibility to insect attack;

In addition Thomson (1974 a,b) charges:

1). Little or no research regarding changes in the ecosystem;

2). Threats to the Australian coastal environment;

3). Secrecy used by the government and State forestry services;

4). Public taxes are subsidizing the adverse activities;

5). They are reducing the hardwood timber for local sawmilling;

6). Monocultures change the original ecological patterns and make them prone to disaster;

7). Clearcutting creates nutrient loss, destruction of complex plant and forest ecosystems, and destruction of wildlife and their habitat;

8). That claims for employment being stimulated are incorrect and suspect;

The total of these effects results in a reduction in the biotic and structural diversity of native forest communities and ecosystems.

With regard to pine plantations and the species Pinus radiata, D. Don, there appear areas of special concern (Calder, 1972):

1). Destruction of extensive areas of diverse natural vegetation to provide land for pines -- loss of habitat;

2). Lack of biological diversity in mature pine plantations;

3). Marked change in the landscape character -- loss of bush landscape;

4). The ecological aggressiveness of P. radiata,

> whose seed is capable of wide dispersal, thus giving it a potential for invasion into natural communities adjacent to plantations and experimental plantings.

"Today we discover that in taming the land we make it less habitable and less beautiful, and our differences, once a source of unity and strength, now seem to be a source of division and conflict" (Meyer, 1975).

Man's technology of today has given him greater powers and fashioned his demands in a way which makes him no longer a part of the natural environment. He has accepted a position which sets him apart from nature. Human nature also has a profound effect on this concept of natural resources for usually the individuals will over-exploit both the land and the things growing on it if this action leads to his own gain (Steele, 1971). Man is in fact destroying or modifying many of the natural ecosystems and their resources on which his existence and advance formerly depended, and to the extent that the consequences are unpredictable (Christian, 1971).

Despite emerging attitudes of concern there will still be increasing demand for those products or opportunities which people seek, far beyond their basic needs and perhaps beyond the level where man can persist in balance with nature.

We still know relatively little of the broad ecological consequences of our present uses of the resources. In the past few centuries of development, competition to acquire power, increasing affluence and the dictates of economic goals, have all led to the establishment of a way of life with certain patterns of resource use. Today's youth is beginning to question the value of this way of life that has become habitual with our society. Rarely has society considered rationing its non-renewable resources for the benefit of future generations, except as rates of consumption and markets may set limits to the rates of exploration (Christian, 1971).

In Tasmania, the lack of land-use planning has led to bitter public controversy. The Lake Pedder Committee of Inquiry proposed the need for a much broader, multi-objective approach to the planning and management of Australia's water and land resources. Most of Tasmania's forested area has been allocated to pulpwood concession areas "demonstrating the need for multiple values in forestry and reinforcing the demand for management to maximise the total weighted value of a system's resources, keeping in mind the requirement that all reservable resources should be managed on a sustained yield basis without impairment to the productivity of the land" (Shepherd, Winkler, and Jones, 1975).

Aldo Leopold (1949) in A Sand County Almanac once said:

> There is as yet no ethic dealing with man's relation to land and to the animals and plants which grow upon it ...the land relation is still economic, entailing privileges but not obligations. All ethics so far evolved rest upon a single premise: that the individual is a member of a community of interdependent parts. His instincts prompt him to compete for his place in that community, but his ethics prompt him also to cooperate.

1-3 The Impact of Intensive Land Use

Biologists have long been aware that the distribution of animals is greatly dependent on that of plants, the dependence of plants on plants, of plants on that of animals; and animals on animals is equally well documented. Some organisms are less dependent than others on the biological integrity of the region. There are always a few adaptable species that persist in an area after most of their neighbours have gone.

The "great tragedy of the Green Revolution as currently pursued, is that it tends to destroy the very diversity that it and the world needs to survive and prosper"(Ehrenfeld, 1972). This destruction is effected in two ways: first through the deleterious side effects of the various chemicals now applied to agricultural (or forest) land throughout the world; and second through the widespread acceptance of the miracle crops themselves (rice, wheat, corn, or Pinus radiata) with the consequence that land managers the world over are abandoning the personal strains of crops that have been in their families for generations. As miracle crops replace or out produce existing plantings, they herald the spread of a deadly agricultural uniformity while an irreplaceable wealth of plant diversity vanishes in their path. The more the Green Revolution succeeds, the more it fails -- under these conditions, no one wins.

Our modern forest practices can cause the loss of gene pools as we increasingly turn to lower cost monocultures which lack the genetic diversity of the original forest cover. None of the threatened species in Australia have commercial value nor have they been planted to preserve the gene pool. The allocation of natural resources is decided upon the basis of community priorities with biological reasons given a low priority. A gene resource is the result of biological development and adaptations over a long period of time, but once lost it is virtually irreplaceable. With continued clearing of native forest and woodland for agriculture and forestry we risk the loss of particular gene resources. Shepherd (1974) states that " forest management must make provision for maintaining the integrity of representative breeding populations throughout major forest project areas " and the " additional cost will have to be accepted by the community as the cost of gene conservation ". Current preservation programmes (State and National Parks) may be inadequate where a widespread species possess great diversity within its distribution range. A series of reserves may be required to safeguard adequately some of our lesser known and studied species of fauna and flora, thus keeping in check the narrowing of the genetic base.

The only way to preserve a species (or variety) is by preserving a sufficiently large population in its native habitat, complete with its own particular requirements for survival.

A general principle is gradually emerging from ecological study to the effect that the more complex the biological community, the more stable (Lutz,1963). The intricate checks and balances among the different populations in a forest look inefficient from the point of view of any particular population, but they ensure the stability and continuity of the whole system and thus the survival of the individual populations. The balance of relatively simple communities (such as monocultures) is more easily upset than that of richer ones; that is they are more vulnerable to invasions (sirex wasp, root pathogens) or destructive oscillations in populations of animals (rabbits or black cockatoos). Generally the fast growing commercial varieties of crops are more susceptible to pathogens than their wild ancestors. Wild rather than cultivated diversity is the principle hope for solving problems of disease and undesirable characteristics.

The single crop system is always in a precarious equilibrium. It is created by man and it has to be maintained by man, ever alert with his fertilizers, insecticides, herbicides, and other chemicals along with man's machines, to protect it against the hazards of some new development in a wounded natural system (Lutz, 1963). The more complex the forest ecosystem, the less likely will be violent fluctuations in the physical environment or its plant and animal components. The probability of survival of an individual or group increases with the degree with which they can adjust to each other and their environment. No species can maintain membership in a community unless it is provided with its minimum requirements and its tolerances are not exceeded.

1-4 <u>The Forest Ecosystem and Society</u>

Gene pools for plants and animals, the simple aesthetic existence of the ecosystem, the value of the forest for timber and other products are all resources of the community. Attiwill (1975) proposes that "too little research attention has been given to those ecological processes which will determine the sustained productivity of our forest resource, particularly nutrient cycling and the regulation of primary production." Most forestry research has concentrated on a relatively few species of major economic importance, half of the money was spent on planting P. radiata in NSW in 1974 (FCNSW, 1975).

The new dimension being given to the social values of natural lands and the rate it is increasing is testing the forester's ability to adjust management policies (Grose, 1974). Perhaps too often the forester adopts the attitude that he is managing his own forest, rather than being privileged by virtue of his special skills to manage a community resource. With newly aroused interests in forests, people have the forester's activities under close scrutiny and show increased interest in the way he manages their forest to provide them with their goods and services. They want to participate in the decision making process. It is essential that decisions involving major change in policy be reached only after all relevant interest and responsible comment has been noted through the process of an environmental impact analysis. Coombs (1972) discusses the matching of ecological and economic realities. Ferguson (1974) outlines multiple use planning in the following steps: 1). Resource inventory; 2). Forecasting future demands; 3). Identifying alternatives; and 4). Evaluation and choice. He suggests that the changing pattern of demand for goods and services has signaled the need to incorporate non-wood goods and services in the planning process.

Florence (1969) suggests that "ultimately the interests of indigenous forest conservation will best be served through the establishment of national land use priorities with land use planning at both the regional and national levels. Future management prescriptions will have to be modified to include other forest uses and ecological factors. Florence (1969) concludes that "forest conservation will ultimately be the resultant of both resource use planning that is sympathetic to all points of view and the quality of management practise in the resource utilisation".

A new public mood recognizes the need for productive forest lands under sound resource management. People want leadership from persons who recognize the values they cherish -- recreation values on some areas, priorities for wildlife, wilderness areas, and some areas of intensive production to supply them with material needs.

Society's demand for open air recreation, wilderness and scientific reference areas is increasing. This is of particular importance in a country where the majority are city dwellers. The Australian Bureau of Statistics (1975) indicates that 85 percent of Australians live in urban areas and 15 percent are rural dwellers. The concentration of populations in cities creates a need for many to escape into open space or rural environments during leisure or vacation time (McMichael, 1971). The land manager's problem is just how big the areas should be to serve the purpose for which they are reserved. For some species and wildlife communities it is critically important for survival that the area should be large enough to withstand the influence of external destructive agencies or to contain sufficient numbers of individuals to ensure population viability. Research is needed before programmes are implemented.

1-5 The Birds

The effects of forestry practices on the avifauna is directly related to their degree of dependence on the forest. For some it is recommended that large reserves are the only means to ensure their long term survival. "The Tall Open and Open forests (Wet and Dry Sclerophyll forests) of South-eastern Australia and Tasmania support a rich and varied fauna of birds and mammals forming the single most important refuge for wildlife in Australia" (Tyndale-Biscoe and Calaby, 1975). In the Southwest of Western Australia the majority of species are in the woodland and sand plains heath formation fringing the Open forest.

To determine the minimum requirements of space and habitat for long term survival, inventories of species need to be prepared for selected areas throughout the range of forests and requirements for each species determined. These should include requisites for individual survival -- food, shelter, and enough space for a population of sufficient size to ensure genetic diversity and gene flow (Tyndale-Biscoe and Calaby, 1975). The factors involved include density, diversity, fecundity, mobility, longevity and social organization of the species.

Each habitat has its carrying capacity determined by the essentials of life. Wild animal populations cannot be maintained permanently at a level above their capacity. The animal's requirements for water, soil, certain plants, other animals, particular climate and parasites are parts of its ecological web, when something is removed it effects the whole habitat. Most animals have very specific requirements for habitat and cannot readily adjust once it is destroyed or altered. Ovington (1968) reminds us that just from bees, Australian honey valued at over $4 million/year is harvested with 90% coming from forest lands. Man needs animals not only for their material benefits but also for the pleasure and contentment gained out of association with them.

Heislers (1974) suggests that multiple use forestry should recognize the need for fauna priority areas.

Natural prairies, woods, ponds and streams once teeming with bird life have been converted into relatively sterile agricultural or urbanized environments, ecologically unsuitable for many birds. Man's tools for modifying the environment: chain saws, earth movers, power sprayers and chemicals combine with bush fires, soil erosion and water pollution to further the destruction of natural habitats. Even without man the forces of nature will continue to effect bird populations. We must hope that man will "acquire sufficient wisdom soon enough to provide a refuge for the most threatened species" (Welty, 1962).

In their natural communities, birds are in equilibrium with the environment. Man's influence has had a profound impact on nature. Disruption of the biological equilibirum has profound effects on bird population and has caused the ruin and eradication of many. The destruction of natural habitats and the reduction or extinction of wild species are now proceeding at an accelerating rate.

Birds were the foremost animals to suffer human action. It is estimated that no less than 150 species have already disappeared for ever (Dorst, 1974). The rate has increased since a precise inventory has been possible. About 10 forms (species and subspecies) became extinct before 1700; 20 during the 18th century; another score from 1800-1850; 50 from 1851 to 1900; and another 50 from 1901 to the present (Dorst, 1974). That is an average of 1 form a year over the last century that has disappeared. The same factors which have resulted in the disappearance of the most vulnerable species have reduced many other birds to a rarity. Man is guilty of almost all the extinctions of birds, as well as other animals.

The causes of reduction and extinction are varied and combine with other factors to affect a single species. Direct action of human predation, slaughter for plumes, egg collecting, vandalism and thoughtless hunting are described in <u>The Great Extermination</u> by Marshall (1966). Man may have an even more profound effect on birds by destroying their natural habitat. An old English proverb sums it up quite well:

> The law goes hard on man or woman
> Who steals the goose from off the common,
> But lets the greater sinner loose
> Who steals the common from the goose.

Throughout the world two major environments are especially threatened and in the most diverse regions have been massively reduced: forest and aquatic habitats. Many examples can be given around the world -- in Australia the Scrub birds are confined to dense scrub, unable to survive their clearance.

The Noisy Scrub bird (<u>Atrichornis clamosus</u>), is represented by about 50 individuals. For more than 60 years it was thought to be extinct (Dorst, 1974).

Ecosystems can also be upset by the introduction of foreign elements. Many bird species have been acclimatized by colonists nostalgic for the fauna of "back home", for game, or to combat pests (examples are European starlings, English house sparrow, domestic pigeons, mynahs, and Ring-necked pheasants). Of special danger to wingless or flightless birds are the European fox, dogs and cats. Even the rabbit has changed the equilibrium through his presence and competition for food.

During the past 20 years, man's efforts to control his environment has permitted his continued increase in numbers, his survival in combat and has meant a great increase in agricultural productivity. Much of this has been achieved by controlling pests, but in Victoria "of approximately 200 products registered for pest control agents, 70% are probably damaging to wildlife" (Bacher, 1967). Manufacturers in the past have shown no genuine interest in the effects of their products on wildlife. There have been losses of birds (and mammals) following the use of "1080" (sodium fluoroacetate) for rabbit control (Bacher, 1967). Many people view the long-term sublethal effects on the surviving population as of greater significance than the direct mortalities. These effects result in reduction of vigour; inability to perform necessary functions; reduction of sight, smell and hearing; effects on muscle coordination and balance; and nervous disorders. During periods of severe climatic conditions or food shortages death of the less vigourous member may occur through starvation. From DDT and other organochlorines the most important effect is on reproduction -- sterility of males, lower fertility of eggs, high mortality of chicks -- and an increased concentration in the food chain.

Through studies of wildlife mortality on a road in New South Wales, Vestjens (1973) found 66% of the deaths involved birds, 29% mammals and 5% reptiles and amphibians. Most birds were killed in the spring or summer while they were still vigorous. He found the highest numbers killed per kilometer were on bitumen roads running through savannah woodlands.

With so many of man's activities working against wildlife it is no wonder conservation groups are making themselves heard. Wheller (1970) and Johnson (1974) discuss some of the rare and endangered birds in Victoria. Ingram (1975) discusses the disappearance of the ground parrot as resulting from the Queensland Forestry Department's drainage of the heath and reducing the size of the Cooloola reserve for purposes of planting slash pine (<u>Pinus</u> <u>elliotii</u>, Engelm). The ground parrot is already on the IUCN redbook of wildlife in danger. Ingram suggests that continued forest activity in the area will also be detrimental to the powerful owl, emu, black cockatoo, turquoise parrot and red faced lorikeet.

"The special characteristics which make the Wallum suitable for banksias likewise make it very suitable for a wide variety of wildflowers and an abundance of native fauna which take full advantage of the honey rich flora and mild climate to build up dense populations" (Sinclair, 1975). In 1970 an economic assessment proposed a long term softwood forestry plantation for the Wallum. Conservationists want the uncommitted Wallum to remain as a land bank and part of it to be put into Wallum National Parks, with the cleared Wallum left by the beef slump to be used for forestry endeavours rather than clearing more native woodlands.

Frith (1969) comments about pine plantations in the ACT saying:

> The extensive clearing of the native trees has meant the destruction of much bird habitat; its replacement by a forest of single exotic species, to which no Australian bird has been able to adapt, has not compensated for this loss. In a mature plantation, a few birds travel through or camp but very few live in it except along the scrubby creeks or in clearings where a few native trees and plants remain.

At the FAO World Symposium on "Man Made Forests and Their Industrial Importance" held in Canberra, 1967, the discussion of wildlife was limited to its detrimental effects of browsing, barking, seed loss and protection methods which included: fences, guns, poisons, traps, fumigants and repellants (Cromer, 1967 and Holloway, 1967).

Payne and De Graff (1975) estimated that $500 million was spent in the United States in 1974 for the enjoyment of non game birds; birdseed, binoculars, and camera equipment accounted for 95% of the total. This outlay surpassed the estimated $180 million spent by waterfowl hunters in 1970. Both estimates excluded food, lodging and transportation of the recreationists.

1-6 The Future

The place which birds occupy in relation to man and his activities has remained essentially the same as in previous ages. They may interfere with our interests on the one hand, and assure us both material profit and intellectual, aesthetic, cultural and emotional satisfaction on the other (Dorst, 1974).

We have the duty to conserve at the highest possible levels even those species which at first might have no practical use.

When Australia was colonized by the Europeans there were approximately 250 species of furred animals and over 650 species of birds spread throughout the land (Pritchard, 1971). Due to the effects of livestock, grazing and land clearing, erosion, pollution, exploitation of timber, river siltation, swamp drainage, dams, bush fires, insecticides, shooting, trapping, poisoning, and the introduction of exotic species (mainly foxes and rabbits) there has been a wide swathe cut through the numbers and habitats of Australian wildlife. Man must cease to destroy so wilfully that which has taken millions of years to achieve in its present form and which, once extinct, can never reappear.

Man must of course modify part of the earth's surface -- especially the part which is directly usable -- to meet our own requirements of life. We can never do again without fields, paddocks, and managed forests. It is certainly not in our best interest to transform the whole surface of the earth. We must preserve the diversity of habitats and safeguard all the forms of life and natural communities which have evolved. This means managing the earth rationally, with due regard to the potentialities of each area and the marginal zones, so that some areas should be absolutely maintained in their original condition, some altered to a certain degree and others will be wholly transformed, according to an integrated plan worked out in accordance with the laws of ecology and not from the sole necessity of money (Dorst, 1974). Birds form a part of these natural communities which we must preserve or manage.

Certain species of birds require very special attention since their extreme reduction in numbers, very limited distribution and vulnerability to adverse environmental factors severely threaten their very existence.

Not only is it within our power to safeguard all birds which still survive, but it is also in our best interests because they form a huge natural combination on which we also are closely dependent. Rational management will be the key to long term prosperity for the greater good of all mankind.

With the study of birds still in its infancy, they must continue to form part of the scenery, for the satisfaction of our inspirational, cultural, aesthetic, spiritual, emotional and educational needs. These are sufficient reasons for including in our management objectives the protection of birds whose very special adaptations make them one of the most remarkable types of living things on earth.

CHAPTER 2

AUSTRALIAN AVIFAUNA

2-1 Number of Australian Birds

Most families of the Old World birds are represented in Australia. About one-third of the total bird species are endemic and provide the characteristically Australian part of the avifauna. Some are of unusual interest because of their appearance and habits; the emu (Dromaius novaehollandiae) is the second largest living bird; the mallee fowl (Leipoa ocellata) lays its eggs in a mound of earth which is warmed by the sun and the temperature is regulated by the addition or removal of soil and decaying materials; the lyre bird (Menura superba) is renowned for its vocal mimicry and dancing displays; and the bower birds (Ptilonorhynchidae) for their decorative nests and collection of colourful objects. Some introduced species have become economic pests; starlings (Sturnus vulgaris), and the house sparrow (Passer domesticus) (Leeper, 1970).

The last Official Checklist of the birds of Australia (2nd edition) was published in 1926 by the Royal Australasian Ornithological Union. Work is proceeding on a new edition at the time of this printing. The list in 1926 contained 707 names. Mayr and Serventy (1944) accepted 651 species as comprising the list in 1944 when they compared it with New Guinea's 650 on a land area almost one-tenth of Australia's.

When including every bird identified in mainland Australia and its dependencies, some experts number approximately 750 (Wade, 1975). Omitting the rare stragglers from other continents reduces the number to about 700. If you include only the residents, it's about 600. And if the list was limited to those birds which occur nowhere else in the world except as regular migrants or occasional vagrants, the number would be about 380 species (Wade, 1975). In 1975 Wade edited the book Every Australian Bird Illustrated which pictures approximately 700 species and will serve as a handy reference to those interested in the Australian avifauna.

2-2 Australia as a Biotic Environment

The Australian continent has a land area of 7,682,300 sq. km. (Aust. Bur. Stats., 1975) and is approximately the same size as the United States, without Alaska. According to Keast (1961) it differs from other continents in the following ways:

a). Spatial isolation from other large land masses;

b). General flatness, mountain barriers to species dispersal being virtually nonexistent;

c). Absence of areas of extreme cold, the winter snowbelt amounting to only a few hundred square miles. There are no permanent glaciers or snowfields. The overall climate varies from subtropical to cold temperate.

d). Generalized aridity. Agriculturalists classify Australia as being only one-third fertile, the remaining thirds being semi-arid and arid. Rainfall is the all important factor governing the distribution of life in Australia.

e). The arrangement of the basic vegetation formations (forming the bird habitats) into broad parallel north-south and east-west zones. The altitudinal zonation of plants and birds that is a feature of mountainous regions of the world is virtually absent in flat Australia.

2-2-1 Physiography

The continent falls into three physical subdivisions: The Great Plateau covering the western half, the Central Basin and the Eastern Highlands. The Great Dividing Range is by far the most significant physiographic feature influencing Australia's climate, vegetation, and diversity of fauna and flora. Among the other mountain ranges of interest are the Flinders Ranges, Mt. Lofty Ranges (SA), Macdonnell's Ranges (central), the Darling Scarp and Stirling Ranges (SW), and the Hamersley Ranges and the Kimberley's of the NW. They all have a marked influence on local rainfall, vegetation and hence the avifauna. The northern part of Australia generally has wet summers and dry winters while in the south the reverse occurs (Keast, 1961).

2-3 Bird Habitats

Little is known about the details of habitat selection by birds, in general it seems that each species is best adapted to the habitat it occupies, otherwise it couldn't survive there. The nature of a given habitat determines the type of bird life it can support. A bird's structure, behaviour and evolutionary history are all related to the environment where the bird now lives and where its ancestors lived (Berger, 1961).

2-3-1 Physical Factors

Although any one of the physical factors may determine the distribution of plants or animals, it is generally the interaction of two or more of them that determines the suitability of the environment for any particular living thing.

2-3-1-1 Air Temperature

A bird's distribution may be limited by high or low temperatures. Low night time temperatures may limit the southern distribution, usually in relation to available food supplies and length of daylight. Birds which nest at high altitudes may withstand extreme fluctuations in air temperature during a relatively short breeding season, where the days are long and food is abundant. During sleep or cold weather birds fluff out their feathers to form an insulating layer of air between their skin and feathers, they also stick their beak under their wings to provide them with prewarmed air to breathe and reduce their body surface. Birds obtain protection from the wind, rain and cold by special roosting habits. High temperature may limit the northward distribution particularly during the egg laying season. Birds will sleek their feathers or pant when it gets too hot.

Nests may be built on northern exposures in the mountains to obtain more sun, or on the east side of rocks in the desert to avoid the sun during the hottest part of day. Most birds of the hot climates restrict their movements to early morning and evening.

Birds maintain resting body temperatures ranging from 37.8 C to 44.6 C and average about 40.5 C (Welty, 1962). There are of course extremes in environmental temperatures beyond which bird's can't survive. These limits vary with species, age, health and other factors.

2-3-1-2 Humidity and Precipitation

Humidity and precipitation have an indirect effect through their control on growth and distribution of vegetation and food. Rainfall is one of the dominating primary influences on birds (Campbell, 1943). The insulating value of feathers deteriorates as wetness continues making prolonged wet weather more destructive than dry cold. Early snows cover food supplies. In the desert, dryness itself may be an ecological requirement.

2-3-1-3 Wind

Wind intensifies the ecological effects of temperature and precipitation as in blizzards or driving rains. Regions with prevailing steady winds present birds with distinctly different environments from less windy regions with similar characteristics. Wind inhibits singing and other activities of birds. Other species seek the wind for soaring or gliding where hills or mountains create thermals. Severe winds can disperse birds to wherever they are carried. Nesting sites are often chosen with regard to the prevailing winds, depending on whether it is needed as an aid in take off, or whether shelter must be sought in holes, or crevices in cliffs or behind rocks.

2-3-1-4 Soil

As with the distribution of plants, many birds are dependent on the amount and kind of soil, for providing food and shelter. Soil of the proper composition is needed by some birds for use in the construction of their nests. Dirt banks of the proper consistency must be available for species which excavate nesting burrows in the ground. Soil may be important because of the presence or absence of certain chemicals which are essential for normal physiological processes (ie. calcium for bones, potassium for egg shells).

2-3-1-5 Light

As an ecological factor, light influences birds mainly through its intensity and duration, and to a lesser extent through its wavelength (colour) and direction. The most obvious relation between sunlight and bird activities is shown by species which are diurnal, crepuscular, or nocturnal in habit. Among diurnal species, some inhabit open areas and others live deep in the woods where light intensity is much reduced. Changing light intensity is related directly to the beginning of song in the morning and the cessation of song in the evening (Berger, 1961). The eyes of nocturnal birds are usually larger than those of diurnal species. The retinas of nocturnal species are rich in rods, while those of diurnal species are rich in colour-sensitive cones (Welty, 1962). The ability of most birds to discriminate colours undoubtedly influences their search for and selection of food. Variously coloured oil droplets in the retinal cells of many birds may well be an adaptation for the precise detection of small objects (insects, worms, berries, seeds) of the same or complimentary colours.

The two natural rhythms of light--daily and yearly--have profound effects on the anatomy, physiology, behaviour and distribution of birds. Diurnal birds are more active and have higher temperature and metabolism during the day. The "many instinctive responses to photoperiodism; singing, courtship, mating, territorial battles, nest-building, egg-laying, incubation, plumage molt and migration are set into motion by the change of daylight" (Welty, 1962).

Other ecological factors such as fire, especially in grassland and woodland areas are needed to perpetuate certain species of vegetation and hence birds.

2-3-2 Biological Factors

2-3-2-1 Vegetation

Plants are of ecological importance to birds, not only as sources of food but also for nesting materials, nesting sites, lookout posts, singing stations and for protective cover. Welty (1962) speculates that vegetation may satisfy some psychological needs in birds as well. While there is a wide diversity in the shapes and sizes of beaks, their adaptations seem to be developed for either a generalized bill capable of eating a wide variety of foods, or towards a specialized bill suitable for eating foods of a restricted type.

Species ecologically tolerant of a wide variety of foods are said to be euryphagous, as shown by gulls and crows. With their straight, simple beaks they can eat fish, eggs, other birds, fruits, vegetables, invertebrates, carrion and other foods. Birds limited to a restricted diet are said to be stenophagous, or if restricted to a single type of food like nectar, pollen or honey, they are monophagous. Other adaptations to food include the food storing crop (in pigeons), seed-grinding gizzard (in turkeys) or the cellulose digesting caeca (as in chickens).

In general seed-eating birds have muscular grinding gizzards, while meat eaters have glandular stomachs that digest food almost entirely by enzymes. In some individual species like the gull, adaptations change its digestive glands used for eating fish to a muscular stomach capable of crushing grain as they move inland in the autumn. An ability to adjust to a different kind of diet at different times of the year is a valuable adaptation for birds living in a region subject to seasonal changes. The food availability could change from insects in the spring and summer, to fruits in the autumn and seeds in winter.

Too narrow a specialization in diet can be dangerous to a species because some catastrophe could destroy the foods on which it depends. Whatever a bird's feeding adaptations and habits may be, it must live in those regions where its preferred foods are found. Slight adaptive changes in the structure of the beak or chemistry of the digestive enzymes might change its diet enough to cause a change in its geographic distribution. These latter changes may require new adaptations in limits of tolerance for temperature extremes, rainfall, nest sites, and other environmental conditions (Welty, 1962). Ecological adaptations can thus be in balance with a bird species or discriminate against a species.

Among the other needs supplied to birds by vegetation is a secure and effective nesting site. Some species show pronounced preferences for specific types of nesting site vegetation. Not only the height but character and density of vegetation helps determine populations. Some species specifically nest in conifers and others in broad leaved trees, some prefer open stands and others dense dark woods. Welty (1962) suggests that birds living in dense woods have louder voices than those of the open habitat. Seasonal changes in the character of the stand may affect the suitability of the habitat for birds. The Ruffed Grouse (Bonasa umbellus) in the USA prefers conifers as cover in the winter and deciduous woods in the summer. Generally, flocking is discouraged by dense vegetation and encouraged by the open formations on prairies, steppes or savannahs.

Other interdependence of birds and plants are seen in the pollination and distributions of plants by birds. Birds which feed on and pollinate ornithophilous plants belong chiefly to the families Nectainiidae and Meliphagidae in Australia.

2-3-2-2- Animals

Other animals compose part of every bird's biological environment and include; mates, offspring, predators, prey, competitors, parasites or symbionts.

Competition is most likely to govern relations within aggregations of birds, particularly if the different individuals require the same essential and exhaustible resources from the habitat -- food, nesting sites, dust baths, lookout perches, song posts, etc.. The keenest competition occurs between birds of the same species because of the similarity of their requirements.

2-3-3- Altitude and Latitude

A person can pass across a series of biomes extending from tropical rainforest to polar ice regions by travelling from the equator to the arctic regions or by ascending an equatorial mountain to an altitude of 4 km.. You would pass through the same successive zones. The advantages of comparing a series of biomes altitudinally rather than latitudinally are a saving in time, money and effort required and the opportunity for a close comparison of vegetation and animals of neighbouring biomes. Some species are tolerant of the varied living conditions of several zones while others are very restricted in their tolerance. Generally there is a greater variety of birds at lower than at higher altitudes where living conditions are more rigorous (Welty, 1962).

2-4 Australia's Bird Habitats

The survival of any bird species depends upon the continuance of suitable living conditions for it, conditions which supply food, shelter, protection and individual requirements peculiar to a species. Most birds have physical adaptations to special circumstances--wings shaped for long flying, soaring, flitting and fluttering; strong beaks for breaking nuts, brush tongues for taking honey and pollen; waterproof feathers; webbed feet or strong claws and come in a variety of colours. All these things aid birds to exist in particular localities and under certain conditions. They also restrict their movements and limit their capacity to survive in unsuitable environments.

"The Australian eucalypt attracts many kinds of birds and is the biggest single factor in determining bird presence and population" (Wade, 1975). Often in the discussion of maintaining natural habitats for birds, financial factors are mentioned. Placing the proper value on bird survival is also a way of measuring the true wealth of a country.

Every Australian Bird Illustrated (Wade, 1975) combines the work of eighty seven photographers and six artists to portray every known species of Australian avifauna. They list the following 24 principal habitats of Australian bird families:

1). Tropical rain forest
2). Tall tropical woodland
3). Temperate rain forest
4). Wet sclerophyll forest
5). Dry sclerophyll forest
6). Temperate woodland
7). Mangroves
8). Semi-aird woodland
9). Arid woodland
10), Alpine woodland
11), Alpine complex
12). Mallee scrub
13), Mixed scrub (Mallee and Mulga)
14). Tropical heathlands
15). Temperate heathlands
16). Saltbush plains
17). Grasslands
18). Spinifex
19). Rocks and rocky outcrops
20). Desert complex
21). Swamps
22). Rivers
23). Billabongs
24). Seacoast and islands

Each of these habitats has its own special set of characteristics making it desirable for some birds and undesirable for others. For a more complete description of the habitats I would suggest _The Australian Environment_ by Leeper (ed., 1970) or Biogeography and Ecology of Australia, _Monographiae Biologicae_, 8. The Hague, Junk (Keast, Crocker and Christian eds., 1959). Frith (1969) describes the bird habitats of Australia's high country and this includes some of the main areas being converted to pines.

2-5 The distribution of Australian birds

The majority of Australian bird species are restricted to, or reach the peak of their abundance in one or another of the basic vegetation formations. If the figures be expressed as percentages it is seen that of the total isolates about 14% are rainforest forms, 33% sclerophyll forest birds, 30% belong to savannah woodlands, 5% to savannah grasslands, 5% live in the mangroves, 5% are residents of the swamps and marshes, 4% survive on the desert grassland, 2% depend on the mallee scrub, and 3% are best adapted to miscellaneous habitats (Keast, 1961).

Before a species can adapt or develop into a new association that habitat must contain certain characteristics basic to that species. Some geographic variation in habitat and ecology is characteristic of all wide ranging bird species. Where closely related species coexist in a single habitat they tend to be specialized for different foods (Lack, 1951).

A bird's adaptations in structure, physiology, and behaviour have been molded through years of natural selection to fit a combination of the physical and biotic characteristics of its typical environment. Every species seems to recognize its own peculiar niche instinctively.

Wade (1975) lists the approximate abundances of avifauna species as: very common - 30, common - 232, fairly common - 251, uncommon - 118, rare - 65, very rare - 16.

There are several types of factors which control the present distribution of a species, or larger category of birds: past history, physical barriers, the ecological conditions which the birds can tolerate and mobility (Van Tyne and Berber, 1971).

In general it appears that birds are limited in their distribution less by the problems of travel than by the difficulty of establishment and maintenance of their territory once they reach it. Competition from other species already established in the ecological niche required by the invading species seems to be the critical factor preventing successful expansion of their range (Van Tyne and Berger, 1971).

The following environmental requirements are related to the distribution of birds: food supply, rainfall, vegetation, humidity of the air, wetness or dryness of the soil, water (to land species), land (to water species), nature and availability of cover, safety of breeding places, texture and chemical composition of the soil, light intensity, temperature (mean annual, winter, summer, during period of reproduction), interspecific pressure, competition and parasitism.

Ecological distribution of birds is the relationship of the bird to the environment of its particular habitat. Even in undisturbed areas, local variations in climatic and topographical features (streams, rivers, lakes, cliffs, mountains) have resulted in discontinuities in the climax vegetation so that small "islands" of different plant forms have occured. When considering the distribution of birds, it isn't enough just to refer to major biomes for they have been broken up by man's activities.

Usually there are ecotones or transition zones when going from one type of plant community to the next. They are characterized by having a wide variety of shrubs, trees and herbaceous plants, which provide more food or cover for birds than areas of uniform vegetation. Ecotones usually support a larger variety of birds than the communities they separate.

Ecological succession is the term applied when the climax vegetation of any biotic community is destroyed by man or natural events with the new vegetation passing through a series of stages before the climax vegetation is reached again. This replacement process doesn't occur when the area is converted to a new species all together, a form of secondary ecological succession must begin with each transitory stage possessing its own typical plants and animals.

Some birds are ecologically intolerant. An intolerant species is one that has a very narrow range of requirements to sustain the life process and seems to be unable to adapt to other ecological conditions. Others are very tolerant and may occupy many different habitats.

Ornithologists have long recognized the fact that bird species tend to be associated with particular habitats. Gannon (1966) found the presence or absence of undergrowth is one of the factors controlling the distribution of many species of birds during the breeding season (i.e. honey eaters). The terrestrial habitats are generally described in terms of vegetation or land use and the species-habitat associations are analyzed in terms of ecological and behavioural habitat selection of birds (Lack, 1933; Lack and Venables, 1939).

"The ecological response of the fauna was considered responsible for the east-west (or mesic-zeric) distribution in NSW, whereas the zoogeographical factors were considered important in the north-south distribution within wet formations" (Kikkawa, 1967).

The basis for classification of bird habitats is usually provided by the structural forms of vegetation, which are reflected by the ecological distribution of bird species. Patterns of resource utilization by birds are complex and never completely matched by hierrarchial arrangements of plant communities. Thus recognized assemblages of bird species for a given habitat may not share the boundaries with plant communities within major formation types, nor is it possible to precisely predict the distribution and abundance of a species in relation to particular features of the vegetation (Mac Arthur, 1964).

Major requirements of the species must be studied in relation to the principal limiting factors of the environment and the habitat's characteristic features. "The dynamic aspect of a species network must also be followed through the utilization of resources by various key species" (Kikkawa, 1967).

Throughout eastern Australia rainforest patches are distributed stepwise from north to south and within each of the tracts the forest is characterized by a unique association of birds, reflecting a peculiar geographical distribution of bird species. Within the rainforest, associations of birds is much more regular than the surrounding dry country. The birds in it may be migratory or sedentary, but their occurrences are regular, unlike birds of the sclerophyll habitats. In rainforests the birds lay fewer eggs and breed more regularly than their dry country counterparts. Events of the rainforest are more predictable but occassionally cyclones, which are the bird's greatest natural worry, can cause disaster for the birds (Kikkawa, 1973).

Zonation of Australia's faunal areas is generally concentric and correlates in places to some of the existing climatic conditions, such as mean annual rainfall, ratio of precipitation to evaporation and the combined effects of humidity and temperature (Leeper, 1970). Keast (1961) also finds there is a general correlation with the vegetation and faunal pattern. Refuge areas are considered to have maintained less unfavourable conditions during the arid periods of the past, supporting isolated populations through the combined effects of local topography, climate and vegetation. Kikkawa and Pearse (1969) conclude that changes of distribution which have occurred in the historical past obscure any deducible pattern of past distribution.

Compared with the semi-arid formation birds, the wet formation birds have the following: a greater proportion of tree-nesting and tree-feeding species, irregular occurrences of small predators and scavengers, fewer large predators and aerial feeders, and more parasitic breeders (Kikkawa, 1974). He also notes "the proportion of insectivorous, ground-feeding, tree-nesting species remains much the same, but among the herbivorous species the proportion of tree-feeding species is greater and that of ground-feeding species smaller in the wet than dry formations". Birds of the semi-arid formations generally have a greater clutch size, with greater variation than birds of wet formations.

It is clear that there are distinct differences in the structure of avian communities between wet and semi-arid habitats in the subtropical regions of eastern Australia. The degree of species association is greater among the wet formation birds which suggests a discreteness of assemblage. Therefore predicting the presence of a rare species by the presence of other species associated with it is higher in the wet formations.

In semi-arid formations the diversity of seed-eating birds is great, suggesting that despite unpredictable rainfall patterns, seeds are not likely to be a limiting factor of diversity (Kikkawa, 1974).

The availability of resources in time and space seems to govern the maintenance of the local species diversity level in a given habitat. According to Kikkawa (1974) it appears that "neither the structural complexity of vegetation nor the stability of the environment is related to the observed species diversity in subtropical Australia".

Small clutch size of tropical forest birds is below the feeding capacity of parents which limits time away from the nest and reduces predation of the young. The use of fruit in their breeding strategy is considered advantageous and a prolonged nesting period of frugivorous young is associated with reduced clutch size for some species.

Lack and Venables (1939) list some habitat factors for woodland birds:

a). Birds of open as opposed to closed woods--certain species of woodland birds occur predominantly in woods where the trees are widely spaced, when they do occur in dense woods it is usually on the edges;

b). Birds dependent on secondary growth--the height of secondary growth differs with individual species from tall ground vegetation to bushy scrub and small trees;

c). Hole-nesting birds--about 20% of Australia's birds are hole-nesters (Disney and Stokes, 1976)--many will use nesting boxes;

d). Birds dependent on tall trees--a number of species only nest in the tallest trees of the canopy, and are absent from woods not possessing at least one such specimen, the required height varies with different species, for some birds tall trees are essential for song posts or take off for aerial displays;

e). Birds dependent on water--the presence of water brings aquatic or marsh species into the woods.

The presence of a rich secondary growth, old trees with suitable nesting holes and comparatively wide spaces between trees are all but absent from typical pine plantations. They could serve as a suitable roosting place in the winter time however, Nearly all birds wander from woods to woods much more in the winter than summer, hence there is a greater tendency for species which occur almost exclusively in one type of woods to stray off to another (Lack and Venables, 1939).

Kikkawa and Brereton (1963) see Australia as a "producer of semi-arid adapted species of avifauna and New Guinea as a producer of moist-adapted species." New Guinea is more effective in producing colonists because its species are pre-adapted to the regions which surround it and Australia's are not.

In most species, once adapted to a specialized habitat, the colonization of a greatly different formation which is at hand seems to be no easier than the colonization of an island far across the sea by pre-adapted forms. (Kikkawa and Brereton, 1963).

CHAPTER 3

3-0 Bird Species Diversity and Social Behaviour

3-1 Bird Species Diversity

Diversity increases in most major groups of plants and animals as you move towards the tropics. This change with latitude is one of the major patterns of species diversity. A similar change occurs when descending in altitude. Structually complex habitats have more species than simple habitats and islands have fewer species than a comparable area on the mainland (Recher, 1971). A common observation of bird watchers shows more species in a forest than a grassland. Each kind of habitat has a different set of species, Kikkawa (1967) has measured this for eastern Australia. MacArthur (1965) considers the pattern of within-habitat diversity to refer to the different number of species which can co-exist in a particular habitat.

Due to the fact that birds are large, conspicuous and mostly diurnal, the most detailed set of studies on species diversity has been made on birds. They conform to the activity patterns of most ecologists and are relatively easy to census. The world total is around 8000 species and Australia's breeding land and freshwater birds total 531 (Keast, 1961). Birds visually orient to their environment and it is therefore easier to predict what the important parts of their environment may be and to measure them (Recher, 1971).

Species diversity can be measured most simply by a species count. MacArthur and MacArthur (1961) have argued that a community in which the species have very different abundances is less diverse than a community in which the species are more nearly equal in numbers. Species abundances contribute more importantly in censuses of species in fluctuating environments or perhaps in non-breeding censuses according to Recher (1971).

Pianka (1966) identifies six major hypotheses which have been primarily concerned with explaining latitudinal gradients in species diversity.

1). Time theory - all communities diversify in time. Older communities are more diverse than younger. The tropics have a longer history of undisturbed conditions than the temperate zones and are therefore more diverse

2). Theory of Spatial Heterogeneity - complex and heterogeneous habitats support more species than physically or structually simple environments. The greater structural diversity of tropical habitats created by more complex plant communities explains the greater diversity of animal species.

3). Competition hypothesis - natural selection in the temperate zone is controlled by exigencies of the physical environment, whereas competition is the more important component of selection in the tropics. More intense competition in the tropics causes finer use of resources and results in co-existence of a greater number of species.

4). Predation theory - predation and/or parasitism is considered to be more intense in the tropics. This reduces the size of species populations below the carrying capacity of the environment and reduces the competition between them for resources and therefore more species co-exist.

5). Theory of Climatic Stability - under stable climatic conditions resources are relatively constant. This allows for finer specializations and adaptations than are possible in habitats with fluctuating resources. The restricted habitat requirements or narrower "niche space" occupied by species in the tropics allows for co-existence of more species.

6). The Productivity hypothesis - other factors being equal, the more productive an environment the greater the number of species it can support.

3-2 Bird Species Diversity and Habitat Diversity

A large area could conceivably support many bird species in three rather different ways: 1). Vertically: each species could occupy all territories living in thin layers above or below one another, the coexisting species showing vertical zonation; 2). Horizontally: the different species could occupy different patches in the environment so that any one point would include several territories, but nearby points would possess different species; 3). Temporally: the nesting seasons of different species could be staggered sufficiently limiting each by a shortage of food for its young at a different time. Each species would be limited in its reproductive success by different factors and all would coexist in the same habitat (Mac Arthur, 1964).

It appears that the number of bird species which a given habitat can support is largely independent of the kinds of birds comprising the avifauna. The number of bird species which can be supported in a given habitat appears to be determined by the structural complexity of the habitat and the degree of specialization reached by coexisting species. Presumably levels of specialization will be determined by the necessity of maintaining population size above the minimum level required to insure reproduction and by the productivity and stability of the environment.

MacArthur and MacArthur (1961) compared censuses on a wide variety of areas in northeastern U.S. to see what aspects of environmental variation control bird species diversity. They determined bird species diversity (b.s.d.) can be predicted in terms of the height profile of foliage density. A knowledge of the plant species diversity of the habitats censused did not improve their ability to predict the number of bird species. Profiles of the vegetation were determined by measuring the density of foliage at a series of heights above the ground (0-2,2-25,>25 feet).

MacArthur, MacArthur and Preer (1962) and MacArthur (1964) suggested that in relatively small areas of homogeneous habitats the number of layers of vegetation was sufficient to predict breeding bird species diversity, but that in larger areas or in heterogeneous habitats there was a horizontal component to diversity. One habitat may support more species than another of comparable vertical diversity because of a "greater internal variation in vegetation profile", that is a greater variety of different kinds of patches (MacArthur, et.al. 1962).

A fairly accurate census of breeding birds can be predicted from measurements of the amounts of foliage in 3 horizontal layers. The abundance of each species is roughly determined by the number of patches of vegetation whose foliage profile is acceptable to that species (MacArthur et.al., 1962).

This suggests many species are rare only because their chosen foliage profile is limited. The main reason one habitat supports more bird species than another is that the first has a greater internal variation in vegetation profile (greater variety of different kinds of patches). A second reason is of course that a forest with vegetation at many different heights above the ground will simultaneously support ground dwellers, shrub dwellers and canopy dwellers. With a few exceptions, the variety of plant species has no direct effect on the diversity of bird species.

MacArthur (1964) summarizes it as follows:

1). The amount of vegetation, measured in area of leaves per unit volume of space, which lies in each of three horizontal layers corresponding to the herbs, shrubs, and trees over 25 feet tall, determines the diversity of bird species which will breed in five acres of that habitat.

2). The number of breeding bird species is greatest when the three layers have equal amounts of foliage.

3). Knowledge of the number of plant species, or their volume, does not improve our prediction of the number of bird species.

4). In fields, brushy fields, and other early stages of forest succession, the actual bird species and their abundances can be predicted from measurements of the variety of patches of vegetation present, by showing that each bird species has a preference for a certain characteristic proportion of foliage in each layer.

When comparing these conclusions from the Northeast U.S. in the Southwest U.S., MacArthur (1964) found in more complicated environments, birds apparently used more than just profile in selecting suitable habitats. Presumably the addition of nest holes and water, changes from hardwoods to conifers, and from sparse to dense foliage, all made significant changes in the suitability of the habitat for many species. Within a habitat the layers account for the number of species, but habitat to habitat variation was caused by more variables than layers alone.

There are some species like parrots and cross bills, which may not make any use of the foliage profile in selecting their habitats but which look for areas of abundant fruit supply. The diversity of such species cannot be predicted from the foliage height diversity. Within homogeneous habitats then, the number of layers of vegetation is sufficient to account for the diversity of breeding bird species. When the area includes such major differences as those between patches of deciduous and coniferous forest, or sparse and dense vegetation, then the number of layers of vegetation is no longer sufficient to account for the b.s.d. (MacArthur, 1964).

Censuses of breeding bird populations in Australia support the conclusion reached in North American studies, that habitat diversity as measured by foliage profile is a good predictor of bird species diversity. It also indicates that the avifaunas of forest and scrub habitats in the temperate zones of Australia and North America have reached equilibrium and are probably saturated. Equilibrium or saturation levels appear to be independent of the histories and ancestries of the avifaunas concerned (Recher, 1969).

It is now well established that bird species diversity in temperate zone habitats is determined by the physical structure or diversity of the habitat (Recher, 1971). The vertical distribution of foliage and the patches of foliage profiles are the most important components of within habitat diversity. Presumably these are a measure of the resources available to birds. The number of bird species in a habitat is determined by the range of resources available and the limiting similarity of resources which can be used by co-existing species (MacArthur, 1965). The range of available resources is increased as the physical complexity of the habitat increases. Productivity and environmental stability will increase the number of species able to use similar resources without competitive exclusion. MacArthur (1965) indicates only physical diversity and perhaps productivity are likely to vary significantly over small geographical areas and hence, are the main explanations for within habitat diversity.

Environmental complexity affords more opportunities to specialist species. The specialization of tropical birds is seen most clearly in their increased vertical stratification and finer habitat selection. The use of different possible foraging techniques and the existence of different kinds and sites of food can result in an increased diversity of habitats, leading to a greater diversity of niches available for bird occupancy. Therefore bird species diversity is a combination of increased specialization in resource utilization and increased habitat diversity complexity (MacArthur, 1965).

Data presented by Recher (1969) suggested that avifaunas of Australia and North America are at equilibrium. He found that temperate habitats on both continents had similar levels of b.s.d. despite differences in the composition of their avifaunas, vegetation, and environmental histories. The number of birds which a habitat can support is independent of the kinds of birds comprising the avifauna. Instead the number of bird species is determined by the structural complexity of the habitat and the degree of specialization of existing species. It is presumed that levels of specialization will be determined by the need to maintain population size above the minimum required to ensure reproduction and by the stability and productivity of the environment. Bird species diversity in continental habitats may be an equilibrium situation between the rates of colonization and extinction affected by the size of habitat and its degree of isolation.

Hooper, Crawford and Harlow (1973) found in 30 forest recreational areas in the Southern Appalachians (USA) that the percentage of cover provided by foliage less than 12 feet high accounted for 56% of the variation in densities of nesting birds. The mixture of coniferous and deciduous foliage greater than 12 feet accounted for 66% of the variation in diversity of birds. Bird densities ranged from 3.5 to 22.0 breeding pairs per 5 acres. Areas with low bird populations were the upland oaks and pure stands of conifers. Both types lack the diversity in the canopy that seems to attract a large number of bird species, the conifer's excessive shading caused a lack of suitable understorey.

Censuses of birds were made in northern Queensland in woodland habitats that were near special features - streams, swamps and rocky outcrops, and in habitats representative of the features themselves. Those features whose habitat was more varied than the surrounding woodland supported a higher diversity of bird species than did the woodland (Dwyer, 1972). Some specific need of a particular species was provided by the feature and that species could now use the area adjacent to the feature. The feature studied importantly influenced the diversity of bird species in contiguous woodland. Dwyer (1972) suggests that influences of this kind upon b.s.d. may be common in Australia and questions the value of using sampling techniques developed for northern temperate avifaunas.

Where a habitat of little diversity is interrupted by a feature of greater diversity, the feature could serve as an important refuge attracting birds in unfavourable times and serving as a dispersion centre in good times for species temporarily excluded from the larger habitat. Measurements of diversity will be influenced by the extent to which different species are excluded from an area of low diversity at a particular time.

The Australian avifauna is characterized by many species that rely largely on nectar which is distributed in a haphazard pattern through space and time. Nomadism is common among species whose occurance and abundance is determined by the flowering of specific plants. It is therefore difficult to select areas representative of larger habitats for predictions about birds because similar plant association may provide quite different habitats due to the timing and availability of flowers for nectar-feeding species. Specialization in resource utilization, or the use of marginal niches is only possible when environmental conditions remain stable and production is increased (Dwyer, 1972).

3-3 Social Behaviour

3-3-1 Food and Feeding Habits

Food is a critical biological factor in the environment of birds. Although most birds give only animal food to their young, adult birds eat all sorts of animal and plant materials. They secure their food from every available source: on the ground, in the ground, on water, under water, on tree trunks, in tree trunks, on branches, twigs, leaves and in the air (Berger, 1961). MacArthur (1965) finds most birds forage within a particular height range of the vegetation.

3-3-2 Anatomical Specializations

Some of the most obvious differences among birds are seen in the numerous bill adaptations for feeding; in hawks and owls the feet also are specialized for grasping and carrying prey. The nomadic crossbills (*Loxia*) are equipped with bills for extracting seeds from pine cones. The bill shape is very similar within the genera of some families but in other groups of closely related genera the bill exhibits wide adaptive specialization for particular feeding habits.

Although most birds carry food in their bills, food may also be carried in a gular pouch or in a crop. The efficiency of the gizzard in grinding up food is remarkable. Many seed-eating birds eat grit, which facilitates in the grinding process.

3-3-3 Types of Food

It is probable that all classes of living things have at least occasionally, furnished food for birds. Not many birds are known to eat the more primitive plants such as algae, fungi and lichen. Most of the types of specialized parts developed by the higher plants have been recorded in the food of birds: root tubers of many water plants (ducks, geese and swans), grass and leaves of many herbaceous plants (emus), pine needles (grouse), pollen and nectar (honey eaters, sunbirds), sap (sapsuckers, hummingbirds) and many different seeds and fruits. The fruit of numerous trees and shrubs is eaten by birds during certain periods of the year.

So many animals, both vertebrate and invertebrate, serve as food for birds that only a brief summary is given here: rodents - hawks and owls; small birds and mammals - eagles, hawks, owls and falcons; reptiles - herons, kingfishers, shrikes; amphibians - cormorants, herons, rails; fish - sea gulls, penguins, kingfishers; the flatworms, annelid worms, mollusks, crustacea, ticks, spiders and numerous other invertebrates serve as food for many birds.

3-3-4 Food Finding and Capture

Some birds watch for the appearance of their prey and then descend upon it (hawks, owls, flycathcers); others seek food through obstacles by raking away the humus and earth with their bills or feet. Still others flush food from its hiding or have mans' moving objects (cars, tractors, and machinery) do the flushing. Small open formation birds use cattle and other animals to disturb their food. Even fire is recognized by some birds as an aid to capturing food. The food of birds varies from season to season with preference varying with availability, geographic location and their age.

Food may be a direct product of the vegetation or it may be a secondary product such as insects, rodents, reptiles, etc. which inhabitat it.

The emu is the only actual herbage eater in Australia apart from some waterfowl. Some other birds including the pigeons, finches and most of the parrots eat the fruit and seeds of plants. A large group of the Australian birds (honeyeaters and lorikeets) eat nectar from flowers, extracting it with the brush tips of their tongues (Cowley, 1971).

Many of the large birds: hawks, kookaburras and ravens, include reptiles, rodents and other small animals in their diet. The majority of land birds are however partly or wholly insectivorous. Most Australian birds have a fairly restricted diet and should their supply fail, the birds must move to a new area or die, as they are unable to adjust to a new diet. Just a few kinds eat a wide variety of foods.

It is common knowledge amongst ecologists and collectors that native trees have many species of insect denizens and other species, usually recently introduced species as for example

Pinus radiata will have comparatively few. This hypothesis suggests that the number of insect species associated with a tree is a reflection of the cumulative abundance of that tree in the particular country throughout recent geological history (i.e. the Quartenary period). This means that the dominant native trees will have most insect species and recently introduced tree species the fewest. General comparisons between the insect fauna of certain trees in Britain, Sweden, Russia and Cyprus support the hypothesis (Southwood, 1961).

The avifauna of the coastal lowlands of south Queensland contains species which are dependent on fruit, seed, pollen or nectar for food, but the majority feed on insects (Gravatt, 1974).

Gravatt (1974) discuss some of these foods for birds and the species which are dependent on them.

> Pollen eaters: lorikeets congregate on flowering eucalypts and banksias. It is thought that the purple crowned lorikeet (Glossopsitta porphyrocephala) may be an important pollinator of karri (E. diversicolor) in Western Australia. The little lorikeet (G. pusilla) may perform the same function in blackbutt (E. pilularis).
>
> Nectar feeders: there are about 15 honeyeaters in south Queensland. Nectar production is high but has certain characteristics. 1). it is produced by flowers which are easily plundered by man, 2). there are no extended periods where nectar is available, 3). due to the mosaic of vegetation, nectar is not greatly discontinuous in space. Highly mobile nectar feeders take advantage of these phenomena.
>
> Seed eaters: Australia as a whole has a large component of seed eating parrots and finches. The Cooloola and Wallum have only a few, the yellow-tailed black cockatoo (Calyptorhynchus funereus) is frequently seen in Banksia and Hakea, but has also learned to exploit P. elliotii and radiata. Species of doves and pigeons which eat seeds are also found in the area.

> Fruit eaters: the area has a relatively low number of fruit eaters; most of those present are restricted to the rainforest patches or are dependent on gardens. The fruit-eating pigeons: red-crowned pigeon (Ptilinopus regina), Wompoo pigeon (Megaloprepria magnifica), top-knot pigeon (Lopholaimus antaracticus) white-headed pigeon (Columba norfolciensis) and brown pigeon (Macropygia amboiensis) are found in the small areas of rainforest such as at Cooloola and except for the brown pigeon, are seen rarely elsewhere. The catbird (Ailuroedus crassirostris) is similarly restricted. There are few fruit-eaters found outside of the rainforest reflecting the lack of this resource and urgent need to conserve it. Fig birds (Sphecotheres viellotti) and orioles (Oriolus saggittatus) are particularly present in winter, the koel (Endynamys scolopacea) eats fruit during its summer visit. Mistle toe birds (Dicaeum hirundinaceum) have specialized on the fruits of mistletoe and silver eyes (Zosterops lacteralis) eat a variety of fruits. Other species which will take fruit include Lewin's honeyeater (Meliphaga lewini) and the black faced cuckoo-shrike (Coriacina novaehollandiae). A characteristic of these species is their mobility, mostly being migratory or nomadic.

Some Australian birds are considered detrimental by man's economic criteria: pine seed eaters - some of the cockatoos; to rice crops - grey teal, black duck, wood duck, magpie goose; to wheat crops - galahs, emus and budgerigars; and to pastures - the native hen (Leeper, 1970).

Water, in the form of fresh water, salt water or dew, is required for drinking by all birds. Most species bathe regularly; the superb lyre birds use the water in mountain streams for the disposal of their nestlings' faecal sac; water in swamps and lakes provide aquatic vegetation and animal life required by many species of waterfowl, waders and herons; fairy martens, welcome swallows, magpie larks and white winged choughs require water for the construction of their nests; and some species prefer to build their nest in vegetation overhanging water or even completely surrounded by it.

3-4 Breeding Behaviour

3-4-1 Territory

By "territory" scientists mean a limited area defended by a bird (usually the male) especially against members of its own species and sex, during at least part of the breeding cycle. Song, aerial displays and display of plumage are among the signals used to warn other males and serve to attract females.

3-4-2 Functions of the Territory

The uses of territories may differ for the individual bird, the mated pair, its family, a colony of birds or a species. Considered broadly, territory produces its effects, including numerous advantages and disadvantages, through the isolation of birds by spreading them apart, by providing geographic stability and by giving its owners certain psychological advantages.

An isolated male in his territory is unmolested in his courtship of any female that may enter his territory. Once the breeding cycle begins, territory reduces interference with pairing, copulation, nest building and the rearing of young. Ownership of a territory provides a monopoly of the food resources nearby and of the nesting materials (a fact of particular importance during adverse conditions). Since isolation means fewer contacts with strangers, fighting is reduced and energy is saved. The hazards of promiscuity are also reduced and family stability is promoted. The monopolistic feature is thought to have arisen out of the drastic nature of intraspecific competition. After all, a robin's worst enemy, his greatest competitor, is not a hawk or a cat but another robin, which seeks exactly the same things from the environment that all robins seek (Welty, 1962).

Dispersion thus promotes the efficient exploitation of food, nesting materials, nest sites and the other requirements, and probably reduces the incidence of disease by reducing contact, and makes it more difficult for predators to find them.

A function of territory commonly overlooked is evolutionary selection within the species. Birds pushed by expansive territorial forces to the periphery of a species's range may be forced into nontypical habitats where they must eat somewhat different foods, use strange nesting material or nest sites, experience new ranges of climatic conditions and so on. Some birds find they may already possess adaptations to the new conditions. Others may lead a hard life and occasionally strike it rich (like the yellow-tailed black cockatoos with pine cones) in the form of evolutionary adaptive divergence encouraged by ecological or geographic isolation.

Another aspect of territorialism is that it gives an individual the advantage of perfect familiarity with one small area. After a bird settles down in its territory and explores its surroundings, it soon learns where to go for food, nesting materials and the best escape route when danger enters his area. (Welty (1962) indicated that a territory confers remarkable psychological benefits on its owner. A bird changes its personality drastically when it sets foot off its own territory. In many species the possession of territory seems to be psychologically necessary for successful breeding. Welty (1962) also notes "the principle of belligerent aggressiveness in its own territory and shrinking timidity in its neighbours' territory has been seen in many species of birds".

3-4-3 Types of Territories

Welty (1962) suggests the following seven general types of territory can be recognized:

1). Mating, nesting and feeding territories: are probably the most common sort. When a territory is of this type courtship, mating and nest building all normally occur within it; after the young hatch, their food comes from it also.

2). Mating and nesting: same as above except the food is found elsewhere.

3). Mating: these areas are restricted exclusively to the courtship and mating, usually they are held by polygamous birds such as grouse and capercaillie in the northern hemisphere and bower birds, manakins and some birds of paradise in Australia.

4). Narrowly-restricted nesting territory: is found among species which defend only the immediate surroundings of the nest, as in many of the colonial water birds: penguins, cormorants, shearwaters, gulls, herons and terns; doves, swallows and birds of prey; and the Australian magpie (Gymnorhina tibicen) which often suddenly and savagely attacks innocent passers-by.

5). Feeding: only a few birds are known to have feeding territories separate from their nests. Size of territories vary with the scarcity of food.

6). Winter territories: many non-migratory species are associated with an area throughout the year but defend it only while breeding.

7). Roosting territory: seem to be the least important and least studied.

3-4-4 Size and Shape of Territories

The following variables aid in controlling the size and shape of bird territories: food, population density, foliage density, time of the year, function of the territory, colonial or solitary habit of life, age of the bird, its individual aggressiveness and the bird's species. There is a rough correlation between the size of the bird and the size of its territory, as well as between its voice and territory size. The bigger the bird and louder his noise, the larger his territory. Sizes vary from a few centimeters in cliff swallows to over a thousand square kilometers for the Golden Eagle (USA), (Welty, 1962).

Aggressiveness varies from season to season and individuals of the same species. Some of the most vicious fighting occurs during the height of the breeding season suggesting some sort of hormone conditioning.

3-4-5 Defense of the Territory

Territories are defended by threats, posture, pursuit, physical combat or the familiar songs. The objectives of defense include: their mates or young, song or lookout post, display area and food. Typically the male arrives first in the spring, sets up his territory, defends it and waits for the arrival of a female.

Generally birds will tolerate other species in their territory and drive out only birds of the same species, particularly males. Singing is the main means of defending territories

3-4-6 Faithfulness to the Territory

Migratory birds tend to return to their natal territory or nearby environment. This attachment seems to increase with age and each additional occupancy of the nest site. A common pattern finds many adult birds returning to their nest territories in subsequent years; but very few young--due to a higher mortality in younger birds; a greater attachment by the older birds and territorial dominance by the older birds.

3-4-7 Selection of Territories

Morton (1975) attempted to measure sources of selection of territories on bird sounds that are derived from the acoustic properties of their habitat. Because all sounds do not propagate equally well in a given habitat, he reasoned that selection would favour the use of sounds that give the greatest broadcast area for a given sound pressure level. The study was concerned with signals used for communicating over relatively long distances including most passerine "song" notes, many passerine call notes, and contact notes used by a pair of conspecifics to remain in auditory contact when they were too far apart to maintain visual contact (Morton, 1975).

In natural environments many factors either reduce sound energy, such as absorption by air, ground and vegetation, or redirect sound energy, as by reflection or diffraction.

Morton (1975) proposed that habitat acoustics produce selective forces favouring certain features of sound signals: pure tonelike sounds within a relatively narrow frequency range in forest birds living near the ground, highly modulated or trilled sounds in open habitat species. He viewed habitat acousitical characteristics as a framework within which other sources of selection, such as sexual selection, selection for species distinctiveness, territory size and pair bond length operate to mould sounds into the structure that we encounter.

Converting native forest into uniform pine plantations and then pruning them to $2\frac{1}{2}$ meters could therefore change the acoustical patterns in bird sounds thus favouring some species (the ground dwellers) and eliminating others (the canopy dwellers while at the same time, man has eliminated several other requirements for the ground dwellers' survival.

3-5 Pair Formation

Copulation is usually timed so that the period of greatest demand by the offspring coincides with the flush of vegetation and abundance of insects. Breeding may take place on the ground, in water, in the air, in bushes or trees, their nests or man-made structures. Infertility, sterility, sperm life etc. in wild birds is not well documented.

Lack (1940) describes 5 categories of pair formation:

1). The sexes meet only at the time of copulation, with either (a) the males meeting at communal display grounds i.e. some birds of paradise or (b) the males remain isolated and display alone, as for example the bower birds.

2). The sexes remain together for only a few days or until incubation begins, either may incubate and rear the young.

3). Sexes remain together for weeks or months but separate when the eggs have been laid and incubation begins, i.e. most ducks.

4). The sexes remain together throughout the breeding season, usually until the young have been reared with pairing usually taking place after the male has selected a territory i.e. a large number of birds.

5). The sexes pair for life and remain together year round. Many resident birds in Australia hold a permanent territory and are thought to pair for life.

The majority of birds are monogamous with copulation taking place only between the pair members. Certain species are polygamous like the ring-necked pheasant and bittern, or polyandrous as the painted snipe.

The age at sexual maturity varies; ducks, gallinaceous birds, pigeons and most passerines breed the year after they hatch. Geese, hawks, owls, gulls and a few passerines breed when they are two years old. Large birds of prey and storks take from four to six years and the Royal albatross takes up to eight years to reach sexual maturity.

3-6 Nests

3-6-1 Functions of the Nests

Nests are mainly used for the protection of the birds, their eggs and developing young from predatory animals and adverse weather during the breeding season. For protection they are built in colonies, camouflaged or built in inaccessible areas. For inaccessibility nests are commonly constructed at the tips of branches, on cliffs or ledges, in burrows or hollow cavities in trees, on isolated islands or over water.

To camouflage, nests are often built of materials found in the immediate vicinity and therefore more inconspicuous; grasses twigs, branches, mosses, lichens or the bare ground are used.

A second function of the nest is to provide warmth for incubation of the eggs. The air temperature may differ beneath pine plantations and the open woodlands. Warm young develop and reach maturity more quickly than cold ones (Welty, 1962).

Use as a supporting platform for the eggs and young is the third function of nests.

The fourth function includes the satisfaction of the urge to breed, build a home, raise young and increases family solidarity and opportunities to educate the young.

3-6-2 Choice of Nest Sites

This of course varies with the species, often the male chooses the site and the female does the nest building. Although the ability to fly seems to make choice of location limitless, there are many anatomical and ecological limitations for different species that prevent a complete freedom of choice. In addition to structural limitations and adaptations such as the availability of mud or water, beaks adapted for wood boring or carrying twigs, suitable ground vegetation and so on, there are most likely psychic factors which influence a bird's choice of nest site (Welty, 1962). Some may require large tree trunks, a dead snag which protrudes above the surrounding vegetation, or a limb overhanging moving water.

Frequently a species will adapt itself to non-typical nest sites due to a scarcity of normal sites or an individual variation in instinctive response. With a lack of suitable nest sites, many birds are found to adapt to artificial bird houses.

Many species exhibit geographical and ecological differences in their choice of nest height or nest site. There appears to be a species preference for a relatively fixed nesting height.

Colonial nesting species present a special case of site selection in which one bird requires a nest site that is surrounded by nests of similar birds. If the area left of native bush in pine plantations isn't large enough for several of these birds to establish territories, none will.

The size of bird nests ranges from the hummingbird's of a few centimeters to that of Australia's mallee fowl, with an earthen mound measuring up to 4.5 m high and 10 m in diameter.

3-6-3 Materials Used in Nest Building

Choice of nesting materials is limited by the habits and habitat of a species. Some transport materials in their talons but most carry them in their beaks. Availability and abundance of materials influences the choice of materials. The materials used may be of plant, animal or mineral origin, or a combination. Plant materials are the most commonly used. Probably the most common type of nest is that made in the shape of a cup, interwoven with coarse grasses and twigs, lined with finer grasses, moss or plant down, situated on a platform of larger twigs or in the crotch of a tree. Many birds decorate their nests with lichens, mosses, brightly coloured or shiny objects, and place flowers or petals in their nests. Animal products include wool, feathers, bones, hair, cast off snake skins, spider webs, and bird's saliva used to cement the materials together. Mineral products include mud, clay, dirt, sand, pebbles and stones.

3-6-4 Nesting Associations and Bird Movement

Van Tyne and Berger (1971) list some of the many types of associations birds have with other animals in regards to their nesting habits. The following is a brief summary of their list:

1). Nesting associations with different species of birds. (a) mixed colonies - gulls and terns, herons and ibises; (b) protective nesting - a number of small birds are found nesting in association with larger birds - cliff swallows near falcons; (c) proximity nesting - species building nests unusually close together as woodpeckers and flickers in the same tree or flycatchers of different species in the same bush.

2). Nesting associations between birds and invertebrates. (a) three species of parrots and five species of kingfishers nest regularly in the burrows of termite nests in Australia; (b) the black throated warbler nests near hornets nests; (c) many insects are found in bird's nests; mostly parasitic on young birds; (d) snails and mites have also been found in nests.

3). The secondary use of nests finds mice remodeling them for their own use, and other small animals or birds using them for shelter, (as well as man serving it as soup).

Birds move from place to place to find the type of environment required by them. These movements may be nomadic wanderings, regular migrations or dispersion from over populated areas. Latitudinal migration as known in the northern hemisphere is not as clear cut in Australia.

3-7 Woodland Birds

There is competition for nesting holes among certain species, but competition for nesting sites between species is generally lacking. Some birds will however use the nests of other species. Territorial behaviour may affect within species density, but there is little evidence of one territorial species affecting another's density. The general impression of Lack and Venables (1939) was "the woodland bird community in the United Kingdom is extremely loosely knit, most of the species are by no means confined to the woods, and many seem quite independent of other bird species".

They felt vegetational factors and not other birds were the primary cause for a species' occurrence. Both mixed broad-leaved and natural pine forests are rich in birds, but plantations of either are correlated with close planting, and a scarcity of both secondary growth and nesting holes (Lack and Venables, 1939).

A study of honeyeaters in Australia showed that many of the smaller species depend on undergrowth for nesting purposes (Gannon, 1966). He concluded that the presence or absence of undergrowth is one of the factors controlling the distribution of many species of birds during the nesting season. It is generally accepted that two similar species having the same food requirements cannot live together in harmony within the same area. "One species must ultimately dominate the other, which will retreat or adapt to a slightly different habitat" (Gannon, 1966).

3-8 Birds and Forest Management

The enhanced definition of forestry which includes functions relating to recreation, streamflow and wildlife, as well as the harvesting of wood, means that the forester no longers can shut his eyes to the biological aspects of land-use, or cover his ears to the cry of concern, beyond the boundaries of his forest reserve. Webb (1968) suggests "the maximum variety of natural and semi-natural communities should be maintained as possible buffers against invasions and unbalance in the landscape". Complex forests provide a wide range of ecological niches for wildlife, which most people are now anxious to conserve by proper management. Webb (1968) further comments that "habitat requirements for animals are as significant as site factors are for trees, forest types and habitat diversity must be characterized in terms of forest elements which are relevant to the species of animal life to be conserved."

The problem of replacing a natural ecological equilibrium with a new one of sustained and higher productivity emphasizes that all environmental features must be considered, since any feature of the environment may affect the success of this new replacement. It is necessary to identify the hazards and inherent weaknesses of land units so that exploitation doesn't result in degradation. By avoiding uniformity and over simplification, zonation and variety should ensure not only stability and high productivity of an area, but also provide diverse wildlife habitats and aesthetic landscapes (Webb, 1968).

The distribution of a particular species of bird may be closely tied to the distribution of a particular plant or group of plants: as the black honeyeater and emu bush, the glossy black cockatoo with black she-oak, the white plumed honeyeater with mistletoe, and the eastern spinebill with plants having long corolla tubes like the pink heath, correa and kangaroo paw (Cowley, 1971). Plant associations within a forest type can therefore effectively be used to classify specific bird habitats.

The species in an area of land usually changes as the vegetation changes with natural plant succession. There are diurnal, nocturnal and crepuscular birds which feed on corresponding types of insects. Besides the regulatory role of maintaining a balance in the forest ecosystem they help in cross pollination of species, scratching and aerating the soil, dissemination of plant seeds and even serve as a warning to other wildlife when danger is approaching. The influence of birds found in the forest is not confined to the forest as many species only require the woods for certain functions - egrets, flame robins, and sulphur crested cockatoos breed in the forests - but spend most of their time in pasture or farm land. Cowley (1971) feels that "quite apart from the beneficial effect birds have on the growth of trees, productivity of the land, control of insects; purely aesthetic and sentimental values would place them high on the list for conservation".

Any management practice or natural ecological process which affects a plant community also affects the birds and animals inhabiting that community. "Thus thinning, logging, clearing, wildfire and the passing of time all affect the bird populations of the forest. None of these practices or processes destroy habitat, they simply change it to the advantage of some species and the disadvantage of others" (Cowley, 1971). Any regeneration process which perpetuates a particular plant community perpetuates the wildlife community dependent on it.

CHAPTER 4

4-0 The Pine Plantation Programme

4-1 Australia's Native Forest

The Food and Agriculture Organization of the United Nations defines "forest land" as: "all lands bearing vegetative associations dominated by trees of any size, exploited or not, capable of producing wood or other forest products, or exerting an influence on the climate or on the water regime or providing shelter for livestock or wildlife".

The total area of forest land in Australia by this definition is 207,204,000 ha (512 million acres, FTB, 1973, or 590 million acres, Leeper, 1970) or a little more than one quarter of the continent's surface. Although scattered, small, and inaccessible for timber production under man's present technology, the trees are valuable for protection of the nation's water catchments, soil stabilization, wildlife shelter and provide aesthetic values, recreational uses and a place to have a barbeque on Sundays (FTB, 1975). An estimated 11,736,000 ha. (29 million acres, Leeper, 1970) of woodland is under private ownership.

Broadleaved trees predominate in about 97% of the total woodland area with 94% of these being eucalypts (FTB, 1973).

The FTB also estimates that rainforest covers 800,000 ha in Australia ranging from north Queensland's tropical and sub-tropical to Tasmania's temperate rainforest.

The total forest area as defined by the 1974 'Forestry and Wood Based Development Conference,' (Forwood, 1974) as of 30 June 1971 for Australia was 42,503,000 hectares, with 1,830,000 hectares of this publicly owned land (04.3%) permanently reserved for purposes other than timber production as National Parks (Aus. Bur. Stats., 1975).

4-2 Australia's Pine Plantations

Australia's first plantation of exotic trees was established last century in South Australia. Various species were tried, mostly *Pinus* spp. and it was found *P. radiata* gave phenomenal growth. The first *P. radiata* was brought to Australia in 1859 in pots for the Sydney and Melbourne Botanic Gardens.

The most extensive commercial plantations of conifers in Australia have been established in the temperate winter rainfall areas of the southern states with an annual rainfall over 750mm and tableland locations between 700-1300m providing the best sites. Radiata pine comprises about 70% of the area of all coniferous plantations in Australia and 80% of all pine plantations (FCNSW, 1972).

In 1970-71, plantations represented 1% of the Australian forest estate but contributed 19% of total timber production. By early 21st century over 50% of the timber produced in Australia is expected to come from pine plantations making up about 3% of the total forested area (Wheen, 1976).

Forwood (1974) recommended a national planting target of 28,500 ha. per annum. The FCNSW (1975) dissects it as below:

Gross annual national planting	28,500 ha
Less estimate of private plantings	8,500 ha
	20,000 ha
Less planting on Commonwealth territories	1,000 ha
Total government plantings	19,000 ha
Less replantings following clear felling of existing plantations	4,500 ha
New government plantings	14,500 ha

Replanting in 1975 would be 5,400 ha. increasing to 28,500 by the year 2010.

To achieve near self-sufficiency it was calculated that the total Australian softwood plantation area should reach 1,215,000 ha. by 2010. The basis of the production plan is a design to give Australia the capacity to be self-sufficient in forest products no later than the year 2010. Softwood plantations, particularly P. radiata were considered the best means of overcoming the deficit of wood, as they provide 10 to 50 times as much wood per unit area per annum as the indigenous forest, yield a better economic return per dollar invested and also provide a more versatile and flexible end product for processing (FCNSW, 1975).

This objective does not imply the ultimate cessation of all trade in forest products. It merely aims at establishing a resource capable of sustaining a supply equal to the demand for forest products, but still with opportunity for both import and export trade. It has been pointed out that it will probably always be cheaper and more practical to import certain speciality lines of paper and forest products than to produce them locally.

In fact, the philosophy of self-sufficiency and national security in relation to wood production was critically examined and rejected as a basis for forest policy in Australia by Ferguson and Parkes (1974).

4-3 Conversion to Pine

The actual planting of pines is usually preceded by a minimum of two years work in the selection of sites, the design, survey and construction of roads; preparation of the site by clearing, burning and ploughing; the raising of plant stock in the nurseries and the organization of a suitable work force.

Existing plantations have mostly been established following the destruction of the native forest (Florence and Shepherd, 1975). A relatively small area of rainforest has been felled to establish hoop pine (*Araucaria cunninghamii*) in Queensland and NSW. Until quite recently little cleared land had been used for plantation establishment.

Eucalypt forest cleared for softwood planting falls into a number of broad categories. The first is coastal plain areas carrying very poor forest, mainly with soils of very low nutrient status. The planting of southern pine (*P. elliottii*, *P. taeda*, and *P. caribea*) in southern Queensland fall into this category, as do some of the radiata plantings in east Gippsland and *P. pinaster* on the Swan Coastal plain north of Perth, W.A. (Florence and Shepherd, 1975). Recreation, water catchment, urban development or conservation are some of the alternate uses of these sites.

The bulk of *P. radiata* in NSW, Victoria and Tasmania are on predominantly sloping country of the Great Dividing Range in altitude ranging from 500 to 1200 m. and having an annual rainfall from 750 to 1500 mm. Close to 60% of Australia's bird species live in the type of areas being converted (Wade, 1975).

Most of the original forest was 20-40 m. tall, encompassing a number of species associations ranging from *Eucalyptus dives*, *E. macrorrhyncha* at the poor end of the scale through *E. dalrympleana*, *E. dives*, *E. radiata* types to *E. fastigata*, *E. nitens*, *E. delegatensis* and *E. obliqua* species associations on the most fertile end of the range (Florence and Shepherd, 1975).

4-4 Plantation Establishment and Management

4-4-1 Plantation Establishment

When a eucalypt stand is to be converted to pines the first step is to market everything that may be sold, and if circumstances so warrant, harvest the poles, posts, and firewood from the area. The next step includes felling the remaining stand with an axe, chain saw or usually bulldozer, including all trees and sizeable shrubs left standing after the harvest operations. Dense stands of trees are reduced to a tangled mass of boles, limbs, leaves, and debris along with grasses, herbs and small shrubs. This of course eliminates the food and shelter along with the nests and young of any birds utilizing the area. Some people prefer to burn the debris *in situ*, others use the windrow method which is more practical for small planting areas or burning an area of sparse vegetation. Ash beds of windrowed materials tend to promote irregular rapid growth of trees in the windrow area.

A successful burn is of great value during the plantation establishment period, planting is cheaper if access is not impeded by unburnt debris. Young trees have a better survival rate if competing vegetation has been removed and its subsequent regrowth is retarded.

Planning for the burning should commence before the burn takes place. It is usual to complete the falling of the original stand some months before the burn, to allow proper drying. Planting areas are usually felled during the spring or early summer (FCNSW, 1972) which unfortunately is a bad time for the bird population. Burning is usually carried out in the late summer or autumn with weather being the critical factor. Again this destroys any late nesting species, along with their food supply and shelter.

Generally speaking, windrows are safer to burn than the broadcast method because of a perimeter around each windrow. Windrow burning is less costly than broadcast burning but leaves the "windrow effect". The broadcast method is usually completed in a few hours.

Sufficient cultivation is usually provided by confining ripping and ploughing to the rows which are to be planted.

Some areas require the added expense of fencing to keep out rabbits and marsupials. The alternative, which is still used in some areas, is to bait diced carrots with "1080" and this unfortunately has the potential of killing without discrimination, whatever animal happens to eat it.

The method pf planting varies from the spade and planting rod to sophisticated planting machines and depends on the operation, money allocation and the topography.

4-4-2 Scrubbing

During the first few years of the plantation it may be necessary to reduce the competition from acacias, eucalypts, she-oaks and other species threatening to take over the young pines. Axes, mattocks, or brush hooks are used to combat the competing vegetation. This eliminates habitat diversity in the early stages of plantation establishment, and thus limits bird species diversity by restricting the habitat. After 4 or 5 years the pines themselves are able to suppress the competition. Hormone type weed killers (2,4-D and 2,4,5-T) may also be used to kill or knock back competing growth before an area is planted. As mentioned in chapter 1 over 70% of Victoria's pesticides are detrimental to wildlife.

4-4-3 Pruning

Pines retain their branches for long periods. In order to produce clear timber, free of knots, pruning operations remove the lower branches from some or all trees in the plantation. Plywood from clear timber and the knot-free lumber both bring higher prices than those of unpruned stands. In NSW most healthy trees are pruned to a height of 2½ m (8 ft) in the first low thinning operation (FCNSW, undated). This eliminates possible nesting sites and foliage diversity for the birds which prefer this height range. The problem for open nesters (thrushes and robins) is that species which prefer a specific shaped fork in a branch or nesting in lower branches experience severe limitations. There is not much variation in branch size or in the angle they grow out from the trees.

High pruning is subsequently undertaken in more valuable stands, and due to expense is limited to about 275-325 stems per hectare up to a height of 6 m., at an age of 11-13 years (FCNSW,1972). As the trees become taller the vegetation between the rows is reduced and ground litter forms.

4-4-4 Thinning

Unthinned stands (6-15 years old) with the canopy completely closed have a limited understorey of bracken patches and a continuous dense needle layer. However this stage usually only occupies about 10 years in a total growing cycle of about 50 year

Planning the number, timing and extent of thinning operations depends on the assessment of the probable effect of each operation on the stand. Other factors considered include the site, quality, future market forecasts and the economic situation for that year. The stocking, degree of canopy closure and understorey vary with each stage and could provide a variety of different habitats for birds (Gepp, 1976). Trees thinned once or twice start to open the canopy with grass and scrub emerging, patches of logging slash and some native vegetation. There are limited flowering trees or shrubs in the pine forests which also limits the number of insects and in turn limits the number of nectar and insect eating birds. Although grass seed is usually abundant, without suitable shrubs or bushes for nesting, some species could obtain food but no shelter or nest sites. The number of different fruits, berries and seeds is very limited in pines.

4-4-5 The Final Crop

After each thinning the stand assumes a more open appearance, with some variation in the undergrowth for a short time. Final crops are usually about 125-172 stems per ha.. Radiata is harvested on a rotation which varies from 25 to over 50 years depending on the site, stand history and market conditions.

Radiata pine has many uses: scantling, flooring, moulding, furniture components, packing cases, pallets, and form work, fence posts, telephone poles, plywood, particle board, cardboard, paper; bark is used for mulching, and wood flour and chemicals are used for plastics and a variety of synthetics (Wheen, 1976).

Pine plantations do fulfill a valuable role in forestry: they produce large volumes of timber, a variety of related end products from a comparitively small area, thus helping to alleviate the huge demand of society for timber from the rest of the native forest. It is not within the scope of my paper to decide whether it is better to concentrate the pines and timber production in a small area, leaving the rest of the forest area for other uses or if we should use a little bit of every forest. If properly carried out, I would favour the use of a small area for intensive management. Pine plantations themselves form a mosaic of habitat types which successively change as the compartments age. They each have their own vegetative and insect species and hence their own faunal species. The diversity is however reduced from that of native habitats.

4-5 Effects on the Ecosystem

Ovington (1971) comments that "surprisingly little is known of the biological consequences following the replacement of native forest with monocultures of alien species, yet it continues to happen throughout the world at an increasing rate". As more governments are attracted by the economic advantages of plantation forestry, through modern technology and chemicals, forestry operations will continue to increase. Very little is known of the biological consequences alluded to above by Ovington for the Australian situation.

Costin (1953) discussed the possible long term effects of exotic species on Australian soils by references to overseas experience and expressed the opinion that the sub-alpine soils of south eastern Australia would be particularly susceptible to podsolization under pure stands of conifers.

Hamilton (1965) concluded the following points: "the conversion of dry sclerophyll forest communities to pure stands of radiata pine can be accompanied by important changes in soil properties and although the Al horizon proved to be the most susceptible, alteration also extended into the deeper horizons of the solum". These effects included increase in: colour value, bulk density, pH, C/N ratio, and decreases in: loss-on-ignition, organic carbon, total nitrogen, phosphorous, exchangeable cations, cation exchange capacity and soluble salts in the Al horizon of podsolized dry sclerophyll soils derived from both decomposed shale and granite rocks (Hamilton, 1965). The direct effect of this on birds would depend on their specific use of the soils; nest building, nutrient requirements or a food source.

It was also shown that with increasing plantation age organic matter content and bulk density became increasingly unfavourable.

Water properties and stream values for wildlife may be affected by clear felling for conversion to pine plantation. Water temperatures rise during midsummer and vary widely, influenced by stream channel characteristics, stream size, velocity, streamside vegetation and topography. Shallow streams are the most responsive to changes in their microclimate. These changes cause direct changes in the fauna and flora populations in the water and thus affect bird populations (Brown and Krygier, 1969).

Eutrophication is indicated by the build up in algal populations as a result of increased food sources in the water, mainly phosphates and nitrates (Cornish, 1975). Nitrates only appear after clear felling if the regeneration is delayed.

Sopper (1975) summarized that in general research indicated a small nutrient loss after clear cutting; forest fertilization studies showed nitrogen concentrations were not drastically increased; and if properly applied herbicides could be used without impairment of water quality. Because water quality is at a premium in Australia, extreme caution should be undertaken, particularly in the mountainous regions that until recently have remained undisturbed.

Equally little knowledge exists of the effects of clearing for pine planting on animal populations. Tyndale-Biscoe and Calaby (1975) distinguish four main headings of animal dependence on the forest: transient species which pass through during migration or infrequently; marginal species whose habitat adjoins the forest; non-dependent residents found in the forest but not entirely dependent on it; and dependent residents which obtain all their essential requirements from the forest. The degree each species is affected by conversion to pines is determined by its dependence on the native forest.

The use of poison for control of rabbits at time of plantation establishment and the use of herbicides to control unwanted weed growth are both potential sources for concern in relation to bird populations. Chemical pesticides are being increasingly used by foresters for the control of unwanted insects, animals and vegetation. The possibility of undesireable side effects arising from the improper use of some of these pesticides has been receiving considerable publicity by the mass media and such books as <u>Silent Spring</u> (Carson, 1962), <u>The Quiet Crisis</u> (Udal, 1963) and the Sierra Club in the USA.

CHAPTER 5

5-0 Birds in Pines

5-1 California and the Australian Capital Territory

Comparative studies were made of native stands of *P. radiata* on the coast of California and in plantations near Canberra, A.C.T.. The California stands are more open with small to large trees and an abundant diverse understorey. The A.C.T. plantations were usually dense, even-aged and possessed little ground cover except litter. Both are restricted in extent by other ecosystems with ecotones exhibiting the greatest diversity. Within the more dense older Australian plantations, "shade tolerant Yellow Robins (*Eopsaltria australis*) predominate, Grey Shrike-thrushers (*Colluricincla harmonica*), Speckled Warbles (*Chrhonicola saggitta*), and transient flocks of White-winged Choughs (*Corocrax melanorhamphus*) are occasionally seen". Bands of thornbills (*Acanthiza*) move through the crown layer, as do parrots; occasionally White-browed Scrub-wrens (*Sericornis frontalis*) frequent litter on the forest floor (Beidleman, 1974).

In native California forests, bands of Chestnut-backed Chickadees (*Parus rufescens*) and Pygmy Nuthatches (*Sitta pygmaea*) are predominant crown workers, moving lower in open brushy forest, with Hutton's Vireo (Vireo huttoni), Oregon Junco (Junco h. oreganus), flycatchers and New World warblers (Beidleman, 1974). Wren-tits (Chamaea fasciata), Winter (Troglodytes troglodytes), and Berwick's wrens (Thryomanes berwickii) frequent the litter and brush; Bushtits (Psaltriparus minimus) and Scrub Jays (Aphelocoma coerlescens) occur in the brush; and the Steller's Jay (Cyanositta stelleri), Brown Creeper (Certhia familiaris) and several woodpeckers are found within the forest.

The Yellow Robin has best adapted to the denser Australian stands with no equivalents in California; the woodpeckers have no equivalents in the A.C.T.. The more diversified Californian stands exhibit a higher, more varied population of bird species (Beidleman, 1974). In time more species should be able to adapt to their new Australian environment.

5-2 New Zealand's Exotic Forests

At present there are about 550,000 hectares of exotic forests in New Zealand, consisting of mainly radiata pine, Douglas Fir (Pseudotsuga menzesii, Douglas) and other pines. When considering the gullies, swamps, fire breaks etc. as part of the exotic forests a wide range of bird habitats are available.

Recently felled areas present a contrast in environment to the shady, standing forest. These areas remain relatively dry for 3-5 years until the next crop of trees provide sufficient shade. This environment produces a different pattern for the bird life it maintains compared to that of the cool, shady forests.

Most urban (generally pests) species - sparrow, starling, blackbird, thrush and finches can be seen in the recently felled areas. Skylarks, pipits, pheasant, and California quail are also present. In the late 19th and 20th centuries, when burning and clearing of native bush for farmland was at its peak, it was predicted by bird enthusiasts that most, if not all the forest dwelling birds were doomed to extinction. After the establishment of large areas of exotic forest it was still considered that native birds would not become established in the areas, due to the lack of suitable habitats and food supply. A New Zealand Forest Products (undated) brochure lists 14 species of native birds found in the exotic forests of the Taupo-Tokoro area. It is considered that the populations of many native bird species found in exotic forests will further increase in the future.

Jackson (1971) lists 26 exotic birds and 54 indigenous birds which have been recorded in the exotic forests of New Zealand. Most of the exotic bird species are at home in the pine forests, having been imported for a variety of excuses. It is a matter of personal opinion whether or not it is good, from an ecological point of view, to have exotic birds taking over the exotic forests as well. Of the 54 native bird species many were just sighted as flying over the pine forests. It is hard to determine from the article how many actually exist - breed, nest and feed - in the pine forests.

5-3 Western Australia

The white-tailed black cockatoo (*Calyptorhynchus baundinii*) has become a regular visitor to all major plantations of *Pinus* spp. in the Southwest of W. A.. The occurrence of these birds has been surveyed from 1965 to 1970 (Saunders, 1974). The pine seeds are enclosed in pairs under bracts forming a hard woody cone. The bracts are torn off by the cockatoo's powerful bill and seeds are extracted one at a time. The birds also chew off green twigs from the pines with occasional damage to the tree leader.

Near the end of the breeding season birds begin congregating in the pines and Saunders (1974) reports flocks of up to 2000 birds. In the six pine plantations surveyed the flocks were from 50 to 300 birds before the beginning of migration. The smaller seed orchard areas are less disturbed or can be protected by detention devices and therefore the cockatoos are not proving to be harmful with regards to seed production for young seedlings.

5-4 South Australia

During a 15 year study, Pawsey (1951) found 21 native species of birds in pine plantations. From observations over a 3 year period Stevens (1975) lists 22 species he has seen in the pine plantations near Mt. Crawford, 17 species were sighted in both South Australia and the A.C.T..

Gepp and Fife (1975) made an interesting comparison of pine plantations and native bush and found 66 species of birds were seen perching, feeding or nesting in the pine forests. The observations were their own sightings during 1974. It is beneficial to see what ages the pines are and types of food the birds eat, for a complete listing see their article.

Sightings of birds were made during a survey of the Second Valley Forest Reserve between January 1974 and July 1975. Gepp (1976) describes pine plantations in terms of four successive age-management classes (young, unthinned, middle aged and old). Fewer birds were seen in the individual growth stages than in the native vegetation. The least number of species occurred in the interior of the unthinned compartments. When considering the total number of birds found in the 4 different growth stages however, Gepp found the number of bird species to be almost the same as that in native vegetation.

The area studied was in the southern Mt. Lofty Ranges on approximately 1600 hectares of pines ranging from 1 to 50 years. Native vegetation of the area is predominantly dry sclerophyll, elevation ranges from 110 m. to 350 m. asl.. Average rainfall is 905 mm/yr. and summer and winter temperature modes are 27 C and 10 C respectively.

Of the birds seen in pine plantations and pure native forests 38 species are common to both, 4 are exclusive to pines and 5 are exclusive to native forest.

Gepp's figures suggest an edge effect with the native vegetation. Most bird species avoided the interior of unthinned plantations. The decrease in number of species in the interior from young to unthinned plantations and the subsequent progressive increase in the thinned, middle aged and old compartments, appears to be associated with concommitant change in vegetation diversity (Gepp, 1976).

5-5 New South Wales

From their own observations and studies the Forestry Commission of NSW (1973) lists 35 species of birds commonly sighted in pine plantations in NSW, 83 occasional visitors and 10 which were sighted within special habitats located in the pine plantations (a total of 128).

Several studies have been carried out in NSW by private individuals. Heron (1973) lists birds of the Orange District, Disney and Stokes have carried out research in several parts of the state and their results are mentioned in Appendix 1. Dricoll (pers. comm.) investigated birds on the Boyd Plateau as a check on some of the conservation groups which were attempting to have the proposed plantation program there stopped. It must be remembered that many untrained persons who partake in surveys for emotional reasons often miss many signs of evidence which the trained ornothologist sees.

H.J. de S. Disney (Disney and Stokes, 1976), Curator of Birds for the Australian Museum suggests that almost any species of bird can be expected to forage in a pine plantation of mixed age classes. He found more species and individuals were observed in Wet Sclerophyll forest than either Dry Sclerophyll or pine plantations, Dry sclerophyll was also more diverse than the pines.

Disney and Stokes (1976) suggest that the combined total of confirmed and presumed breeding species is the most practical assessment of the breeding numbers in the census area. Of the Australian land birds 19.7% always or usually nest in hollows or in stumps (Disney and Stokes, 1976) but in native forests 35-40% nest in holes, compared to 11% in the pine plantation area where snags and culls were left.

A study carried out in Sunny Corner State Forest by Disney and Stokes (1976) led to the following conclusions:

> All birds breeding in the first thinned pines were insectivorous, none were nectivorous or frugivorous which were frequent in dry sclerophyll and abundant in wet sclerophyll. The insectivores which nested in the pines were gleaners and flycatchers. Brown Thornbills (Acanthiza pusilla) feed in the foliage of the canopy and low in the few plants that grow among the pines. White Browed Scrub Wrens (Sericornis frontalis) sometimes feed in pine trees, but spend most of their time in trash from the thinnings. The robins (Eopsaltria australis; Petroica phoenica and P. multicolor) fed chiefly on the ground, catching insects, but the whistlers (Pachycephala pectoralis and P. rufiventris) fed among the foliage and branches of the canopy. The Grey Fantail (Rhipidura fuliginosa) was seen at all levels. No introduced species nested in the native forest, but the Goldfinch (Carduelis carduelis) breed in the pines.

Over six times more pairs of three times as many species were found breeding in wet sclerophyll than pines. The total number of pairs breeding in pines was slightly greater than in dry sclerophyll, however the diversity of species was twice as much in the dry sclerophyll. One-third of the native species of birds (most common in the wet sclerophyll) didn't nest in dry sclerophyll or pines. Of the 15 most common breeding birds in native forest, only 6 nested in the pines (Disney and Stokes, 1976). Thus the breeding diversity is two to three times as great in the native forest as in pine plantations and the greatest diversity of species is found in the wet sclerophyll, the main type of forest being considered for additional conversion to pines according to Routley and Routley (1973).

5-6 Tasmania

Fielding (1976) conducted a study in northern Tasmania and found the following results:

Birds of the closed pine forest: the understorey varied from none in Australian Forest Holding's plantations to blackberry, bracken fern and tree ferns in the Forestry Commission plantations. After 5 hours of observations in the centre of pine plantations 9 species were observed or heard calling in the pines.

Birds of partly logged mature plantations: with a more open habitat, after 5½ hours of observations 14 species were observed in this habitat.

Birds on margins of mature plantations: 8½ hours were spent in the logged and unlogged margins of the pines and from the firebreaks and tracks within them resulting in the observation of 21 species.

Birds in young plantations (1-3m tall): in 3 hours of observation a total of 17 species were sighted.

The total of species found in all plantations was 29, with 4 of the species occurring in all 4 stages of maturity. 20 species were observed in a native forest in ½ hour of looking, it took 12 hours to find the same number of species in pine plantations. Due to the nature of this study, careful limitations should be placed on his results. The main point is that very little work has been carried on birds in Tasmania's pine forests.

5-7 Queensland

The Tibrogargan Southern pine plantations in the Glasshouse Mountains area was visited by Curtis in mid-December 1973 to obtain a tape recording of the bird songs. Curtis (1974) listed 29 species for the plantation, with 2 additional species being noted in March 1974.

The high bird population was attributed to the re-establishment of other plants, mainly native species, within the plantation perimeter. These plants provided food in the form of fruits and seeds with associated spiders and insects. No bird species which obtains food by scratching in the litter on the ground were noted (Curtis, 1974).

Bird observations were made in 1963-1967 and in 1973 within the Beerburrum complex. Of 101 species recorded, 58 spent a variable time in plantations and 43 were restricted to adjacent or included pockets of native vegetation (Bevege, 1974). Nesting and breeding data indicated 12 species show partial adaptation to pines and 2 species have completely adapted in areas where the understorey provides significant native vegetation (Bevege, 1974).

5-7-1 Birds in Queensland's Native Pine Plantations

The variety and density of bird life in a plantation depends largely on the variety and density of the native understorey which can establish itself in the plantation area. There is no doubt that population densities of birds endemic to the original rainforest have decreased with the advent of Hoop Pine (*Aracaria cunninghamii*) plantations (Fisher, 1974). It is possible that some are no longer present, a considerable range of species may still exist and some may even have increased in some ecological niches of the native pine plantations.

Cowley (1971) considers that most birds present at the time of clearing a new area for plantations probably die. After plantation establishment, activity is mainly restricted to insectivorous species and raptores, with the greatest amount of activity occurring on the edges. The variety increases as ground cover is attained and more food becomes available allowing graminvores to obtain food also. As heath develops small birds including warblers, finches, wrens, silver-eyes and even quail expand into the edges of the plantation for feeding. Following crown closure, birds of the rainforest floor and lower trunks are found in the plantations (Cowley, 1971). Diversity of species gradually increases with increasing complexity of the understorey.

Hoop pine is unique in the Australian softwood spectrum of plantations in that plantations of *Pinus* species do not support such diverse undergrowth favourable to the native fauna (Fisher, 1974).

5-8 Victoria

An 8 week wildlife study in 1972 (Kloeden, 1972, 1973) for APM Pty. Ltd. compares pine plantations and adjacent native eucalypt areas in the Longford and Silver Creek tree farm areas.

In April and May 1972, at the Longford tree farm, 42 indigenous bird species were sighted in the native forests and 29 within the pine plantation areas (Kloeden, 1973). During January and February of 1972, she recorded 34 indigenous birds in the native forests and 31 within the pine plantations at the Silver Creek tree farm area.

Gullies, swamps and scrub areas, although usually not carrying pines, are considered a necessary substratum of pine plantations. The gullies vary from a thin strip of native vegetation passing through a pine compartment to a creek with varying amounts of native vegetation. Swamp areas within the pines usually have not been planted and still contain some original species. Most scrub areas within pine plantation areas are the results of plantings which have failed for one reason or another.

At Myrtleford research began in 1971 aimed at defining the suitability of Pinus radiata habitats for the various fauna and flora which occur in the peppermint forests of north east Victoria. 82 species of birds are known to occur in the native forest areas around Myrtleford, with 70 of these being recorded in the eucalypt forest study area (Suckling, G.C., Backen, E., Heislers, A. and Neumann, F.G., 1976). Of these 70 species, a total of 35 occur regularly in the pine study area; with 19 in the young pines, 23 species in the intermediate pines and 29 in mature pines (Suckling, et. al., 1976).

Of the 35 species found in the pines, 27 breed in one or more pine study areas. Four others were observed feeding flying young within the pines. The 4 remaining species were not observed breeding in the pines. Results indicate that about 16 species breed in the young pines (Suckling, et.al., 1976). It is thought that in all 31 of the 35 species occurring in the pines regularly are likely to breed in at least one of the three different aged stands (Suckling, et.al., 1976). Territory mapping found most of the nesting species live entirely within the pine plantation area.

Of the 82 species occurring in the native forest, 43 obtain a significant amount of their food from the eucalypt canopy. Of these, 30 species were not observed in pine stands and it appears that either the pine canopy lacks the insect species upon which these birds feed, or that these 30 species are not adapted to feeding in pine stands.

A total of 32 native species and 2 introduced species are now known to occur regularly in the Myrtleford pine plantations, of these, 19 native and the 2 introduced species were found to have nests with eggs in the pine plantations (Opie, ed., 1973).

Of 66 species seen in mixed eucalypt forests at Creswick, at least 35 ventured into a 30 year old pine stand (Heislers and Ealey, 1971).

The influence of remnant native vegetation is profound, only 2 species of birds are possibly adapted for coexistence within dense P. radiata, the Brown Thornbill and the White-browed Scrub Wren (Suckling, et.al., 1976). Other species were recorded in the perimeter areas near other vegetation, particularly along streams with eucalypt forest strips (which may have included their entire territories), (Suckling, et.al., 1976).

In the Macedon Ranges a study of the birds was carried out in July 1975 to Feb. 1976. Of 153 species found in the area, 28 (18%) species were observed to some degree using the pines (For. Comm. Vic., undated).

In other studies at Myrtleford, (Suckling, Heislers, Neumann and Backen, 1973) found 24 native and 2 introduced bird species regularly occurred in pine plantations at Slaughteryard Creek and Running Creek in 1972. 19 of these plus the 2 introduced species and an additional 38 native species were recorded in the eucalypt forests of the area.

The species in pines vary according to age classes and stand type of the forest. This variation is related to changes in vegetation, principally the understorey, that occur during the rotation of the pine forest. Suckling, et.al. (1973) found: 10 species occurred regularly in unthinned 22 year old stands; 15 species in thinned 22 year old stands; 18 species in 8 year old stands; amd 19 species occurred in a 44 year old stand which had been thinned several times.

Several of the species which can obtain food among pine limbs and foliage or from needle litter and which shelter in the pine trees, occur in all stands, the Yellow Robin, Brown Thornbill, Golden Whistler, Rufous Whistler and Grey Thrush (Suckling, et.al., 1973).

It was determined that 3 species (Kookaburra, White-winged Chough, and Pied Currawong) feed from the ground litter in pines, but apparently can't forage in the dense understorey of young stands. 11 species require an understorey for food and shelter with 4 of these (Rufous Fantail, Oliver Whistler, Whipbird and the Pilot Bird) requiring continuous cover of shrubs.

Suckling, et. al., (1973) found 4 of the other bird species (White-browed Scrub Wren, Blue Wren, Red-browed Finch and Gold Finch) which rely on understorey vegetation occur with the previous 5 species in young pines and are absent between canopy closure and first thinning when most of the understorey is dead or eliminated, returning after an understorey of herbs and grasses has become established.

The remaining understorey species (Silver-eye, Blackbird) apparently favour blackberries and occur in pine stands where this exotic pest has become established also.

The Crimson Rosella (Platycercus elegans) occurs in all pines over 8 years of age. It feeds on seed obtained from the understorey in young stands and from pine cones in the older stands (Suckling, et. al., 1973). Other birds with limited distribution are the Painted Quail (Turnix varia), Wonga Pigeon (Leucosarcia melancleuca), Scarlet Robin (Petrocia multicolor), and the Ground Thrush (Zoothera dauma). They are found in mature pines. The Bush Bronzewing and Lyrebird are confined to young stands and the unthinned 22 year old stands respectively.

The status of each species can only be estimated, because no banding has been carried out in these studies.

Seven other species occur in pines, but obtain only a small part of their food there (Flame Robin, Pink Robin, Grey Currawong, Bufftailed Thornbill, Quail Thrush, White-throated Tree Creeper, and the Mistletoe bird) during specific times of the year (Suckling, et. al., 1973).

With the limited number of studies or surveys undertaken in Australia regarding birds in pine plantations and the large amount of variation between studies, it is difficult to come up with any critical analysis of the sampling techniques, methods used and the respective results. I have included in this chapter a cross section of the types of efforts carried out in each state which can be obtained from available reading sources. While much work has been done in some areas (particularly Victoria) a lot more research must be carried out before effective resource management can be implimented.

CHAPTER 6

6-0 Conclusions

6-1 The Philosophy of Land Use Management

The need for our concern has now been aroused and now is the time for changes in our approaches to wildlife conservation and management. Poole (1974) contends that too few forestry and wildlife schools provide their students with the proper ecosystem understanding of their chosen profession. If multiple use is an arguable public land management objective, why should everything be based on the rotation of the timber when herbs, grasses, birds, mammals, fish, etc. have a much shorter rotation?

Florence (1973) acknowledges that value judgements will inevitably reflect the particular philosophy and background of the person making the judgement. The attainment of a high standard of planning will be expensive, yet Florence sees it as a small price to pay for foresters to retain their right to continue to make and implement management decisions on public forest land.

Garlaukas (1975) says that based on ecological principles, environmental management produces the least disruptive decision -making path by using interdisciplinary intergration of multidisciplinary knowledge. Through an environmental management framework of specialized views and objectives we can merge to guide society toward a compatible existence with nature with the relationships and interdependencies viewed and assessed in total perspective. Environmental management is a systematic recognition and control of potentially disruptive activities through the use of an interdisciplinary framework.

Kimmins (1972) feels that "only by considering himself as a natural component of the environment will man realize that environmental degradation is directly harmful to his own self interests as well as those of other organisms with which he shares this planet." Kimmins (1973) describes the forest as a complex ecological system of interacting, interdependent, living and non-living components which includes a highly variable layer of soil underlain by parent material, a varied collection of plants of different sizes arranged into a number of definable vertical layers with a characteristic group of animals associated with these plants, a wide variety of microbial forms of life such as bacteria and fungi and finally the atmosphere including water which permeates through all other components. Far too often the forester has been concerned with just the commercial timber component of the forest.

Birch (1973) suggests an "appreciation of a given resource system at the desired level of structure and function may take little account of the gap between a scientific understanding of the system and that actually held by the resource managers who make the actual decisions."

Economic criteria nearly always dominate the choice of how a particular area of land should be used, and the value of tangible commodities is conveniently quantified "in terms of money." Some economists have attempted the valuation of intangibles in terms of "opportunity cost or willingness to pay." The economic horizon is arbitrary, very short and geared "to making money." In agriculture and grazing it is generally 7 - 10 years, in politics it tends to revolve around election years, forestry is based on an economic horizon or 40 years or longer, depending on species or site (Webb, 1974). Webb adds that we need flexibility and diversity in resource utilization with maintenance of the resource in a condition which will enable it to provide what we need on an indefinite time scale and cater for the preservation and enhancement of essential items of the non-economic environment which cannot be substituted by economic criteria.

Helliwell (1973) discusses priorities and values in nature conservation and suggests the following:

> 1) Other things being equal, it is evident that priority should be given to the conservation of species which are rare, of actual or potential material value to man. Very often these will be the larger species of animals and plants which can only survive under a limited range of ecological conditions.
>
> 2). A wide distribution of habitats of different types should be maintained and each of these should be of a diverse rather than uniform character.
>
> 3) Land use planning should have some regard for nature conservation, even where other uses have a greater economic importance.
>
> 4) Access to areas which contain habitat or species which are vulnerable to disturbance may need to be restricted in some cases.

5) Undue fragmentation of wildlife habitat should be avoided.

Sinden (1974) makes an analysis of the conflicts involving tangibles and intangibles. He suggests that we are vaguely aware of some want for these products labled "intangible, incommensurable, environmental good, indirect benefit, non-wood good, or non-market good", which we obtain from the forest, but we haven't established in monetary terms how much we are willing to give up to get the product. A wildlife refuge could benefit those who live near it, those who visit it, or those who never see it but are satisfied just to know it exists. The distinction between the resource (forest), the product (song, sight or beauty of a bird), and satisfaction (utility) is very important. Sinden and Smith (1975) found that the "popular" argument that conversion of native ecosystems to softwood has deleterious effects on the amenity of an area may be wrong. They found solitude or the lack of other people to be a more important criteria than the nature of the forest itself in explaining personal preference for an area. Crowding explained 25% of the variation in choice with people prefering forested to non-forested sites irrespective of the nature of the tree cover. For management purposes they found that a range of 16-36 persons can be tolerated without significant loss of total benefit (Sinden and Smith, 1975).

The development of a detailed land use plan depends on having adequate knowledge of the environmental criteria which when combined with technological and economic factors will determine the maximum output which can be obtained without degrading the site. The problem with forestry activities is that while the physical environment is relatively stable, technology and economic conditions change relatively fast when compared to the rotation of a forest (Stocker and Gilmour, 1974).

Matthew (1972) discusses the need for diversity of habitat and treatment regarding wildlife conservation in forest management.

In the USA, the Endangered Species Act of 1973 has been the cause of much concern in the forestry sector as the act affords protection of the species themselves and their critical habitat (Hutcherson, 1976). A species' critical habitat may be characterized in one of two ways: in terms of geographical location alone or plus individual environmental factors. The Endangered Species Office has recommended that the following criteria be considered: "space for normal growth, movement, or territorial behaviour; nutritional requirements; sites for breeding, reproduction, or rearing of offspring; cover or shelter; and other biological, physical or behavioural requirements (Hutcherson, 1976).

Tyndale-Biscoe (1969) says the wet sclerophyll is ecologically the richest of the eucalypt associations, providing a variety of sub-associations of species, depending on differences in soil, slope, aspect and local rainfall and temperature, and providing habitats for many species of wildlife. Large areas of this type have been selected for conversion to pine because of high growth rates. It is yet to be determined next century whether the soil will continue to sustain such growth rates on future rotations.

The Conservation Council of Victoria (1974) opposes categorically the clearing of native forests on public land for the purpose of planting exotic species or even native species. They suggest that plantations are a commercial enterprise and should compete with agriculture for the use of land rather than the forestry commission converting public native forests into plantations.

Mutch (1974) feels a poor characteristic of managed systems is that they offer progressively less multiple use and lose diversity as the intensity of management increases. The diversity of the unmanaged ecosystem provides built in safe guards against catastrophies. Most land use decisions follow the sequence of ecologist; economist; politician and administrator (Mutch, 1974).

In agreement with Lutz (1963), Shepherd (1974) and Ehrenfeld (1972); Pederick (1974) comments that "genetic change is taking place in the forests as a result of forestry practices, particularly direct seeding and planting, which is resulting in the replacement of original genetic pools by introduced gene pools of unknown quality. Pederick suggests that samples of gene pools should be conserved for future reference of each species and that a comprehensive programme should be undertaken to evaluate the genetic resource of important species to identify the best provenances to be used in various localities and to provide a basis for intensive tree breeding, this could apply to other species as well.

Florence (1968) comments that the application of ecology to forest management implies a management approach based on an appreciation of and concern for the biological complexities or pattern and process within the forest. This implies that the management prescription will not prejudice the stability and productivity of the forest and that any controlled re-orientation of forest composition and structure will not adversely affect the potential of the forest for timber production, water yield, and habitat and wildlife conservation (Florence, 1968). Society is now beginning to say it will not tolerate wood production programmes which are carried out so cheaply that they destroy or restrict other forest values. The profession has the technological competence to provide society what they are asking for, but it can't provide them all at the cost of timber alone (Florence, 1972).

6-2 Land Use Management for Wildlife Conservation

The density and health of a wildlife population are a direct reflection of the quality of its environment and amount of food available per ha., availability of food and shelter throughout the year, and availability of nesting sites during the breeding season. There will be a substantial cost to properly manage these areas for wildlife, the same as it would cost to manage it for any other use. If the community wants effective wildlife management then it has to be prepared to spend large sums of money, if money isn't made available the people will see the wildlife populations diminish at the expense of other demands.

The direct role of trees in wildlife management is to provide refuge and breeding sites for birds and harbour insects, or to provide its foliage, seeds, fruit and nectar for food.

(Heislers and Ealey, 1971). A tree's indirect role in wildlife management is to provide suitable habitat for birds by controlling the microenvironment and understorey vegetation. Trees can be hardwood or softwood, native or introduced, young or old, living or dead, sound or hollow, standing or fallen; with the greatest variety creating the greatest diversity of bird life (Heislers and Ealey, 1971).

For many bird species the change to a completely alien ecosystem based on introduced conifers would be impossible, but it is likely that most would adapt to a compromise situation in which some part of their original habitat was allowed to remain (Williamson, 1972). Williamson (1970) found the density and diversity of bird life, particularly among summer visitors to be high where young conifer plantations were surrounded by a "landscape fringe" and where "island refuges" of deciduous trees and shrubs were allowed to remain of at least ½ ha. in size. He found isolated areas had a higher capacity for birds than several isolated trees which didn't possess other habitat requirements. Territory size differs even among closely related species, for some species as long as their requirements are found in some part of the area, a viable territory can be held (Williamson, 1972).

Johnson (1972) speculates that birds which protect a territory to ensure the use of an area large enough to feed their expected young, highlights the fact that the area of habitat available inevitably limits the number of nesting birds. The number of territories available during adverse seasons represents the maximum long term breeding figure. Johnson (1972) feels that if sufficient bird reserves aren't retained, bird populations will evolve into climax numbers of introduced species and the few native species which are able to profit by the new conditions created by man.

Murton (1971) points out that in New Zealand, of 130 species originally introduced, at least 24 have become established mainly in the man-made habitats. Of at least 24 species deliberately introduced into Australia, 12 have become established with only the blackbird managing to invade the native forest, the remainder are dependent on urbanization and agriculture to create more habitat for them (Murton, 1971).

The stability of the environment will determine how many closely related birds can live in the same habitat without competing for the same food resources. The amount of energy needed to maintain a stable community is less than that required for an unstable one. Man's activities have tended to reduce complexity and introduce monotony, through uniform rows of trees, similar houses, agricultural crops and so on. Animals which inhabit these uniform environments usually fluctuate much more than those of complex ecosystems, often to the extent of becoming pests. The loss and increased rarity of so many birds of prey depends not so much on persecution, but on reduced complexity of the environment through man's never-ending "progress". Our future policies should not concentrate too much on bird protection per se, but rather on the creation and maintenance of as much diversified habitat as possible (Murton, 1971).

Bacon (1969) states that a more varied forest flora with pine plantations could be created by leaving patches of native vegetation, wider fire lanes with herbs, grasses and small shrubs, and that many understorey species could provide food and cover for wildlife without interferring with commercial timber growth. We need to plan for tomorrow's recreational, pyshic and aesthetic needs as well as man's physical needs.

Under normal circumstances any particular area of land can support only a fixed number of birds of any one kind. Conversion of eucalypt to pine plantations causes major changes to the bird populations. The initial clearing probably results in the death of most of the birds and other wildlife formerly occupying the area (Cowley, 1971). A new range of species that favour the open grassland or heath type habitats will occupy the cleared area for a few years. In older plantations there are a few species of native birds which have adapted to feeding and breeding in the pines.

The variety and density of bird life in a plantation depends largely on the diversity and density of the native vegetation that becomes established and on the size of the plantation. Because pines are wind pollinated and few species of flowering plants exist in pines, the supply of insects and nectar as food sources is limited. Native forest patches and unplanted areas, which include grassland and patches of shrubs, occasional trees and swamps, provide the greatest habitat and food source diversity for birds in the pines. Composition of the understorey can be controlled to some extent by the original clearing and preparation techniques, the cleaning and scrubbing, and pruning and thinning operations. Some of these remove desirable understorey needed for bird's nesting, cover and food source.

MacArthur (1965) finds most birds forage within a particular height range of the vegetation. There also appears to be a species preference for nest height. Many birds, especially migrants, return to their natal territories. Other species may be tolerated in a territory but birds of the same species are usually driven out. For many then, it isn't just a matter of fleeing to the nearby scrub when conversion of native forest to pines is taking place as that territory is already established. The distribution of a particular bird species may be closely tied to the distribution of a particular plant. Pinus radiata comprises 80% of the pine plantations in Australia and current plans are to extend the plantation area to 1,215,000 ha. by the year 2010. In general the fauna lacks diversity in pine plantations and variance in results of studies could occur depending on who carries out the research and what is actually considered as pine plantation. Some studies have included only areas of actual pine planting and establishment, while others include the buffer zone ecotones and even the filter strips of native vegetation as part of the overall pine plantation area. Recent Australian studies (Kikkawa, 1967, 1974; D'Andria,1968; Recher, 1969, 1971; Cowley, 1971; Kloeden, 1972, 1973; Suckling et.al., 1972, 1973; Bevege, 1974; Curtis, 1974; Saunders, 1974; Beidleman, 1975; Gepp and Fife, 1975; Stevens, 1975; Wade, 1975; Disney and Stokes, 1976; Dricoll, 1976; Fielding, 1976; and Gepp, 1976) indicate a wide range of birds can be found in pine plantations. They also report that fewer species of birds are sighted in pine plantations than adjacent areas of native vegetation. Fisher (1974) suggests similar results in Queensland's Hoop Pine (*Aracaria cunninghamii*).

Backen *et. al.* (1972), Fisher (1974) and Gepp (1976) found that fewer species were seen in unthinned plantations than in other growth stages, with the interior of unthinned plantations being "relatively devoid" of native birds.

Odum (1971) reported that ecotones are particularly important for populations of birds and Cowley (1971) suggests that boundaries are the best places for bird observations in pines. Fisher (1974) states overall habitat diversity is increased by tracks and firebreaks.

Beidleman (1975) suggests ecotones associated with dense young forests exhibit the greatest bird diversity.

Pine plantations support larger populations of many smaller birds that require shelter than an equivalent area of grazing land (Gepp, 1976).

Basically, it has been shown that few birds have adapted to a complete existence in the pine plantations themselves where they eat, breed, nest and live, although many have territories which may extend into the pines from native forests for a variety of reasons. The native Australian flora has also suffered at the expense of pines but if sizeable and representative examples of native vegetation are retained and understorey is allowed to reestablish in the pines, at some expense to growth rates of the pines, the multiple uses of the forest ecosystem may survive.

CHAPTER 7

7-0 Recommendations

Many of the conservationists or preservationists have shown concern through emotion, protests, anti-forestry campaigns etc. but haven't really submitted any ideas to help remedy the situation. They would like to preserve everything, but still like to have their own homes, read books and printed matter, enjoy their own forms of recreation and make a suitable living. The fact that most of them evidently are employed elsewhere than in the forestry profession or industry makes it easier for them to see only one side of the problem.

The Report of the National Estate (1974) suggested that there is no justification for proceeding with the pine programme by clearing native forests and every effort should be made to restrict needed pine plantings to degraded farm or pastoral land and land of low productive potential for agriculture which is already cleared. There is ample biological evidence to support this point of view as being an admirable conservation policy for us to follow.

The Australian Biological Resources Study has been implemented to inventory the fauna and flora and its distribution in relation to habitat. Much is still unknown and while the study proceeds, we would do well to modify our present practices as far as possible to take into account what is already known to be useful conservation practices.

Forest land managers must decide whether snags and culls shoul be cut for fire protection or safety reasons, removed for firewood or commercial wood fiber, or left standing for wildlife.

Bevege (1974) suggests adding a 5% allowance to Steele's (1971) figure of 10% retention of native vegetation for conscious wildlife management, to allow for (a) greater seasonal climatic variation experienced in Australia compared to the United Kingdom, and (b) due to the more extensive lack of wildlife management procedures in plantation areas. An overall figure of 30% reservation was suggested for the Beerburrum complex, independent of National Park, to ensure wildlife and aesthetic values of the area would be preserved and that the community could see with validity the multiple use of forestry was not incompatible with pine plantations (Bevege, 1974). This is sound policy which should not greatly complicate our current management or make it unduly expensive. A conservative average of the maximum size allowed for clear cutting and conversion to pine forest from Cowley (1971), Recher (1971 Helliwell (1973), Bevege (1974), Curtis (1974), Gravatt (1974), plus the works of Welty (1962), MacArthur (1964), Webb (1968) and Williamson (1970, 1972) would be somewhere around 200 hectares.

Visual encounters of wildlife include photographing, painting, sketching, or just seeing them. Even seeing only evidence of animals like territorial marks, abandoned nests, tracks, dust baths, broken egg shells, scats or the signs of a capture by other wildlife add to a person's enjoyment of wildlife. Listening to animal sounds and recording them is a growing form of wildlife appreciation. Managers can increase opportunities of wildlife encounters through prescibed burning, varying harvest techniques, manipulating timber harvests, feeding programmes and maintaining diversity of habitats. Such attempts to provide for the public enjoyment of forest plantation areas should also entail only a minimum rescheduling of forest management activities.

7-1 Recommendations for Future Developments

The following points appear to the writer to be worthy of serious consideration in developing a better approach to place and function of wildlife in Australian forests generally -

1) Forest visitors should be introduced to the basic concepts of wildlife ecology and management; including the relationships of habitat diversity to density, diversity, competition; and ways of managing forest diversity through prescribed burning, planting programmes, and management techniques.

2) Ornithology should be introduced as an undergraduate course in the Zoology Department at the Australian National Univeristy, with cooperation with the Forestry Department to eliminate schedule conflicts so that interested foresters would at least have the opportunity to study about birds and know how forest management activities will affect wildlife conservation.

3) The use of a multidisciplinary approach for the identification and evaluation of specific impacts of management techniques which coordinates the diverse interests of many specialized agencies should be introduced to Australia's forestry commissions.

4) Ways should be sought to encourage the governments to subsidize the maintenance of diversity in plants, animals and management techniques, to enable nature's diversity to compete with

man's technology of monocultures.

5) Ways should also be sought to place a correct value on intangible goods if economics continue to be the basis for decision-making.

6) Attempts should be made to modify current practices as far as possible so that wildlife management for birds should, in certain selected areas, be based on the life cycle of birds not trees, and habitat requirements of birds rather than site factors of the trees they live in.

7) Attention should be paid particularly to the retention of gene pools, especially the interdependence of birds with particular tree species associations. Samples of gene pools from each species should be preserved for future reference and a comprehensive programme undertaken to evaluate genetic resources which identifies provenances peculiar to specific localities.

8) The Forestry Commissions should be encouraged to create innovative interpretive services for visitors including movies, slides, talks, nature walks, campfire programmes, nature centres, books, maps, brochures or personal contact with the public. Suggestions could be made on how to encounter certain types of wildlife (location, time of day, season) and what precautions to take in order that it is not disturbed.

9) Since most birds forage at a particular height range and build nests at specific heights, artificial nest boxes and bird feeders (including nectar bottles, grains and fruits) may have to be supplied in pine plantations as an added cost of conversion to satisfy demands by the public. As a public relations move I would suggest letting handicapped persons,

old-age groups and the scouts coordinate such activities, which would be subsidized by the government and serve a useful purpose to both man and birds.

10) As the wildlife values of dead and dying trees (or culls) are numerous, decision making guidelines should be determined to recommend the retention of some predetermined number and species which are valuable to wildlife.

11) The placement of roads, campsites, buildings and picnic facilities could be planned so that lesser amounts of overstorey are removed. Planting groups of shrubs in recreational areas would provide for more nesting sites and cover for birds, as well as more privacy for campers and picnickers. In lower site quality areas, less facilities should be established. Amenity plantings along roads, around dams, picnic areas, lookout towers etc. should include species known to provide food for native birds.

12) In conversion areas, a 25% retention is recommended which includes a representative sample of the complete range of environmental conditions including topography. Native vegetation should be retained 100 meters on either side of perennial streams or watercourses. 15% of the overall retention should be within the actual perimeter of pine trees. Ideally 1 ha. should be retained for each 6.7 has. cleared, with irregular boundaries which follow the contours and features of the landscape. 10 one ha. reserves would possess 4 times the length of useful ecotones for birds to extend their territories into the pines, as one 10 ha. reserve. Research will have to determine the best size and shape to suit all aspects of multiple use

forestry. These areas could be occasionally thinned, prescribe burned, used for firedams or recreation areas.

13) Roading, site preparation, timing of burning, planting, fertilising, pest control, scrubbing, pruning, thinning etc. should all be planned to minimize their effects on wildlife and water quality.

14) The size of cleared areas for pines should be limited to 200 ha. with at least 10 chains of native vegetation in between to limit its adverse effects on wildlife, the ecosystem and people.

15) If properly managed, it would not be necessary to hide or screen forestry activities from the road with buffer strips, the public should be allowed to view what is being done in their forest, and the forester should be able to explain why it has been done this way and be proud of his endeavours.

16) Alternative methods for controlling pests should be found, sex attractants (insect pheromone) and sticky traps could be used on insects attacking the pines, sterilants or non-persistent chemicals with selective toxicity should be sought and used on undesirable animal pests.

There is unlimited potential for improving pine plantations for wildlife. First there has to be a demand for action from the public, then an allocation of funds from the government or private interested groups, then research can be carried out and proper management programmes implemented so that multiple use of the forest becomes reality instead of some misunderstood term found in forestry textbooks or quoted by emotional conservationists.

Appendix 1

A1-0 The Oberon Forest, New South Wales

A1-1 Background and Description

Since European settlement in Australia, New South Wales' native forest has been reduced about 24 million ha. to around 16 million ha. at present (FCNSW, 1973). Of this forested area about 1 million ha. are within national parks or nature reserves.

Pines have been planted in NSW since 1914. In the Oberon area pine planting commenced in 1929 at Jenolan and Vulcan State Forests. A review of pine forests after World War II indicated that plantations near Oberon were amongst the most successful in the state regarding health and growth, besides being close to the Sydney market. The planting has been continued to the present. By the end of 1974 22,300 ha. of pine plantations had been established in the Oberon area with plans for an additional 32,000 ha. (FCNSW, 1974 and Harper, personal comm.).

The main tree species being converted are *Eucalyptus fastigata*, *E. dalrympleana*, *E. viminalis*, *E. dives*, *E. radiata*, *E. pauciflora*, and *E. stricta* (Harper and Fussell, pers. comm.).

Some of this total area of 22,300 ha. was marginal farm land infested with serrated tussock and pines were used to get the land back into production (Dog Rock State Forest).

The planned rate of planting by the Forestry Commission in the Oberon Area is about 2100 ha. for the next 10 years (Harper, pers. comm.). Part of the Boyd Plateau was planned to be converted to pines because an economic assessment decided that was its most valuable use for society. The ACF and Colong Committee (both undated) put out literature and held meetings to stop the so called tragedy. The conservationists won this battle and the area has been turned over to the National Park Service.

A1-2 Bird Studies

Several persons have carried out bird studies in the Oberon or adjacent area. Heron (1973) lists birds of the Orange district; Disney and Stokes (1976) carried out a study on the Sunny Corner State Forest which compared birds in native forests and pines and also on the Winburndale Reserve; Dricoll (1976 and pers. comm.) studied birds on the Boyd Plateau and in pine plantations on the Jenolan State Forest; and the National Parks and Wildlife Service (Morris, 1974) and Forestry Commission of NSW (1973) have lists of birds found in the area. Most of these species lists are similar.

The diversity of bird species in native forests is significantly greater than in the pines. Bird species diversity, number of species and eveness of abundances show a similar pattern between habitats and seasons, with a drop in the winter.

The FCNSW hopes that the Oberon plantation projects will ultimately extend from 60,000 to 80,000 ha. as the basis for a major forest industry (FCNSW, 1973).

A1-3 A Look at the Oberon

(All photos taken by D.A. Kuehn, 1976)
Type of native forest being converted to pine plantation.

Pine plantation first season after establishment.

Appendix 2

A2-0 The Wombat State Forest, Victoria

A2-1 Background and Description

The area of reserved forest in Victoria as of 30 June 1975 was 2,295,236 ha. (For. Comm. Vic., 1975). 64,650 ha. have been planted to pine plantations with Victoria's nurseries dispatching over 10,080,000 softwood seedlings in 1974-75. A total of 4,287 hectares of native forest was cleared for softwood plantations in 1974-75 (For. Comm. Vic., 1975).

The Wombat State Forest comprises about 73,000 ha., mainly of reserved forest straddling the Great Dividing Range between Macedon in the east and Ballarat in the west. It is administered from three forest districts based at Daylesford, Trentham, and Macedon.

About 20 eucalypt species occur in the forest at elevations ranging from 100 m to almost 1000 m and rainfall varies from 600 mm to over 1000 mm at higher elevations. The principal commercial timber species are *Eucalyptus obliqua*, *E. rubida*, and *E. radiata*.

Fire hazard in the summer is relatively high, the present crop of oldgrowth originated from selective logging and fires dating from the 1850's onwards. The forest has been exploited for mining timber, fuel and building materials.

Management of the Wombat forest is based on multiple use and the forest has been divided into the following classes for management purposes: (For. Comm. Vic., 1974)

Select Hardwood 32,000 ha.	Medium to high quality eucalypt forest on undulating topography - suitable for sustained yield of sawlogs.
Softwood conversion 14,000 ha.	Medium to low quality eucalypt forest on undulating topography - includes area suitable for pine conversion.
Minor produce 5,000 ha.	Low quality eucalypt forest suitable for posts, firewood, etc.
Protection 22,000 ha.	Low quality eucalypt forest on steep to undulating topography. Generally unsuitable for commercial purposes.
Special areas 200 ha.	Includes nurseries, research areas, etc.

Due to its nearness to Melbourne, which includes 70% of the state's population within its urban areas, forest recreation is rapidly becoming a very important factor in management decisions on the Wombat forest (Calder, 1974 and For. Comm. Vic., 1974).

A2-2 Fauna studies

As in New South Wales, several wildlife studies have been undertaken in the Wombat area: Heislers (1971, 1973); Townsend

(1975); and the Forests Commission, Victoria (1971, 1974, 1975, and undated). The Daylesford area also possesses its own conservation group "Save Our Native Bushlands Action Group". The lists of species and findings are similar to those of Suckling et. al. (1976) who undertook studies on the plantations at Myrtleford; and Kloeden (1972, 1973) who carried out a study in Gippsland. Pine plantations are less diverse and although numbers of actual individuals are often similar between native bush and pines, the bird species diversity in the pines is much reduced.

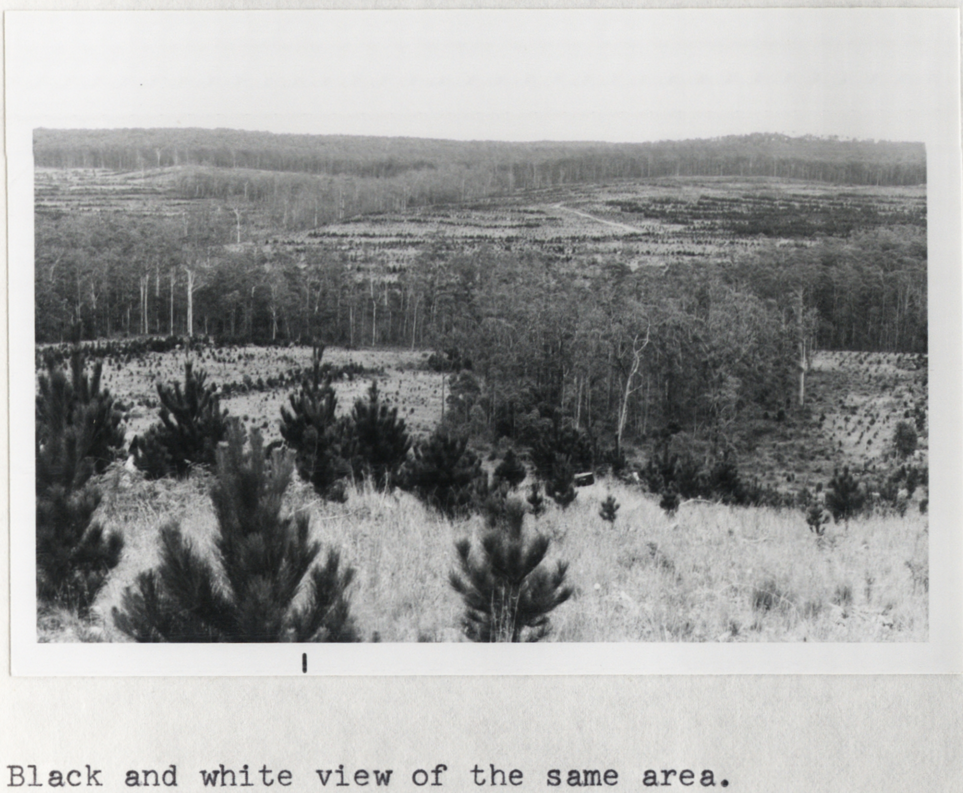
A2-3 Status of Fauna Today

Recent studies (Heislers, 1971) record 17 species of native mammals and about 70 species of birds. Most of these occur throughout the forest but a few favour specific habitats such as dense undergrowth, damp gullies or particular eucalypt associations. No birds have been eliminated or are in danger of extinction (Heislers, 1971) on the whole of the Wombat Forest. It appears that viable areas of representative vegetation types have to be safeguarded from conversion. At Creswick, it was found that 35 of 66 species use the plantations, but not necessarily in the same numbers which they use the native bush (Heilsers, 1971 and Backen and Middleton, 1973).

Where conifers are maintained, wildlife interests must be safeguarded through management practices which produce a maximum diversity of habitats.

A2.4 A Look at the Wombat Forest

3 year old pines in Spargo Plantation, showing the filter strip.



Black and white view of the same area.

Appendix 3

A3-0 The Fingal District, Tasmania

A3-1 Background and Description

The total state forest area for Tasmania at 30 June 1974, was 1,281,840 ha. (FCTAS, 1975). A total amount of $382,000 was spent on the establishment of pine plantations, in 1973-74, excluding the cost of roads and other improvements. The area of *Pinus radiata* planted in 1973-74 was 1900 ha. bringing the state softwood plantation area to 23,200 ha. (FCTAS, 1975). Average growth rates of Tasmania's plantations are 50% higher than the Australian average (Cunningham, 1974).

The pine plantations were begun in the Fingal area in 1962 to help employ local residents who had lost their jobs in the mining industry (coal, tin, tungsten, etc.) (Davies, 1965). Employment figures for the pines varied from 110 in 1965 when 900 ha. were planted to 70 in 1971 when 837 ha. were planted. Currently about 77 persons are employed during the planting season (Boyden, pers. comm.). As of 1976, 10,240 ha. of pines have been established in the Fingal area (Boyden, pers. comm.).

The main species of native bush being cleared are: *Eucalyptus obliqua*, *E. pauciflora*, *E. salicifolia*, *E. sieberi*, *E. ovata*, *E. viminalis*, *E. regnans*, *E. delegatensis* and Tasmanian Blackwood, with the understorey consisting of native hop, native pear, musk, heath, bracken fern, wattle and native cherry.

Neilsen (1975) carried out a land classification and consideration of plantations in the Fingal Valley. He found much of the area was unsuitable for conversion to pines because of poor soils and site factors and refutes the myth that radiata pine will grow well on marginal sites. Rainfall in the area ranged from less than 500 mm to over 1300 mm.

Most forestry papers (Unwin, 1973, Cunningham, 1974, and FCTAS, 1974) acknowledge that varied habitats are necessary for a diversity of wildlife, but little research funds are devoted to wildlife management. Burgess (pers. comm.) comments that little work has been done on birds in the Fingal area, and that some studies have begun to survey animal signs in the native forest near Triabunna, but as yet the programme has not been extended to pine plantations.

A3-2 The Avifauna

Tasmania's avifauna includes 104 breeding species of native birds, of which at least 20 migrate regularly to the mainland (Ridpath and Moreau, 1966). Fielding (1976) has studied birds in pine plantations elsewhere in Tasmania; Wall (1971) discusses a Royal Australasian Ornithological Union field-outing in the Campbelltown area; Recher, Thomas and Milledge (1971) list bird species for a census of dry sclerophyll along the Lake Leake highway. They concluded that to restrict the vegetation growth to a few species would greatly reduce the number and kinds of animals able to survive. Thomas (1974), Williams (1974) and Lake (1974) dicuss many of the problems associated with the conservation of Tasmania's avifauna.

In contrast to the Oberon area and Wombat State Forest, very little work has been done regarding the effects of pine plantations on native wildlife in the Fingal area. The government was initially concerned with employing the miners and little consideration was given regarding the ecological consequences of their endeavours. The conservation movement is growing in Tasmania, with a lot of bitterness against the Lake Pedder hydro-electric programme and more recently the woodchip programme. As more people become concerned with the ecological problems of managing the environment, more research will have to be done. At the moment, Tasmania seems to be placing its priorities elsewhere.

Little research has been done anywhere regarding the psychological and sociological effects that converting native forests to pine plantations has had on people, let alone the bird populations. Some will of course not be bothered, others will have to travel further to obtain their own special requirements from the bush; mushrooms, berries, honey, firewood etc.. For some it will mean that they no longer get to enjoy the bush landscape in their immediate area and some will miss certain species of fauna and flora.

A3-3 Views of the Fingal Area

Recently cleared area to be planted to pines, with roads and firedams constructed.

4 year old pine plantation with Ben Lomond in background.

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